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ABSTRACT

This publication describes the Sustainable Seas Expeditions which is a five-year project of ocean exploration and conservation focusing on the National Oceanic and Atmospheric Administration's (NOAA) national marine sanctuaries. This resource book is the first in a two part series. This first teacher resource contains an introduction to the Sustainable Seas Expeditions and Web sites along with background information. There is a listing of the National Marine Sanctuaries, and four classroom investigations are included. Investigation One examines marine species. Investigation Two takes a closer look at one sanctuary. Investigation Three plans an expedition while Investigation Four designs a submersible. Investigation Five uses charts to explore marine sanctuaries. Invesigatio Six examines how an oil spill will affect a national marine sanctuary. Finally, Invesgiation Seven looks at a sea turtle's life cycle. A glossary and a listing of teacher resources are also provided. (SAH)

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Sustainable Seas Expeditions Teacher Resource Book, Units 1 [and] 2

Pam Larkin, Editor

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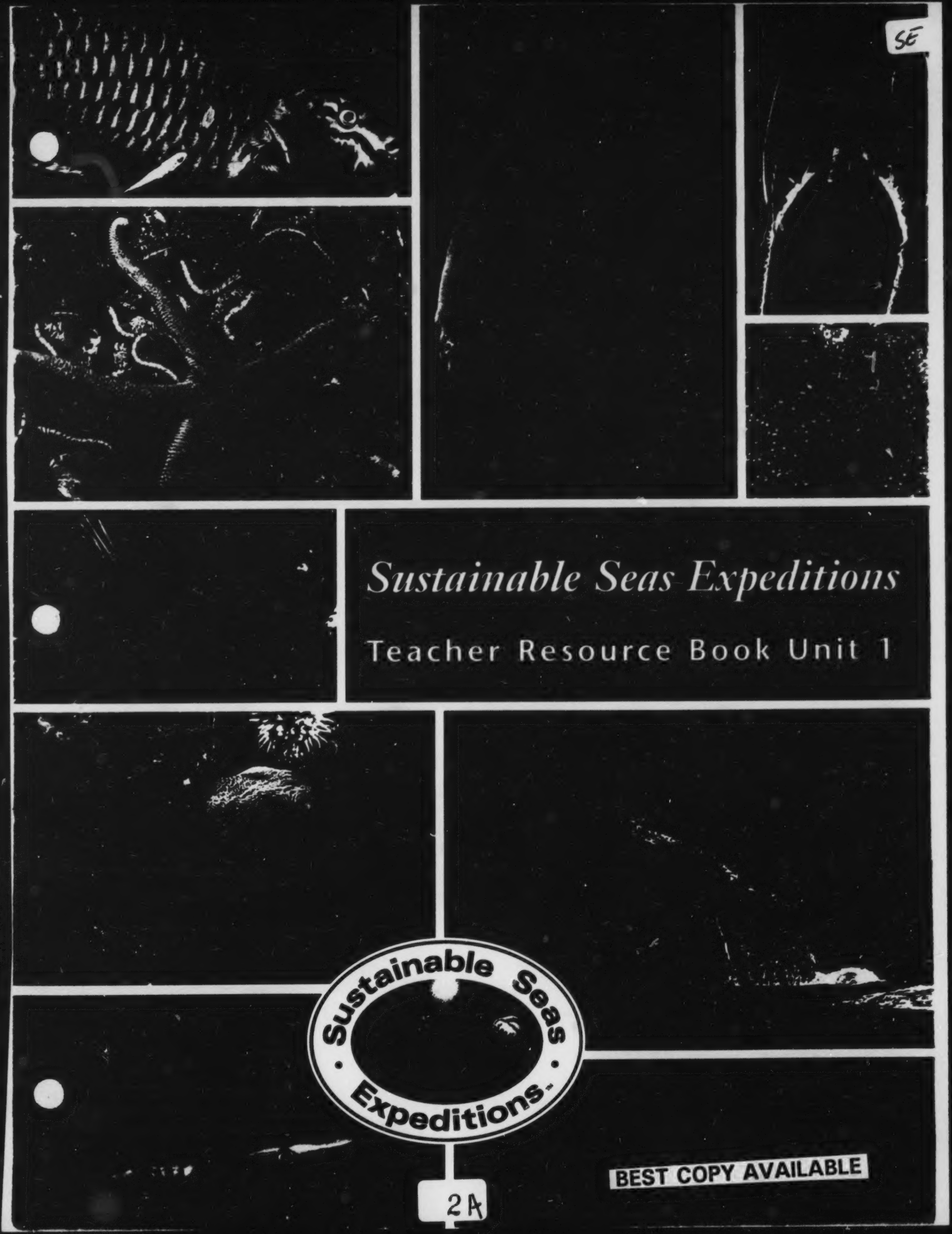

Sustainable Seas Expeditions

Teacher Resource Book Unit 1

Sustainable Seas Expeditions™

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2A

Sustainable Seas Expeditions

Teacher Resource Book
Unit I

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National Marine Sanctuaries
NOAA
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Introduction to Sustainable Seas Expeditions

by Dr. Sylvia Earle

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Dr. Sylvia Earle

Throughout my career as a scientist and ocean explorer, I have dreamed of making ocean exploration and research accessible to more people. Blessed, as I have been, with the ability to go into the ocean, see its marvels and puzzle over its mysteries, I come back from every dive longing for others to have such experiences. Children, fellow researchers, politicians, poets—anyone and everyone should have a chance to explore this ocean planet. With new insights personally gained, there is hope that we will be inspired to do what it takes to protect the natural systems that support us.

In 1998, the National Geographic Society invited me to become their "Explorer-In-Residence." Partly, I think, because of my experiences. But also because of my dream to use research and exploration as a way to energize as many new "Ocean Citizens" as possible. A little later, the National Geographic Society, the National Oceanic and Atmospheric Administration (NOAA), and the Richard & Rhoda Goldman Fund announced an exciting and unprecedented mission into the oceans. With a five million dollar grant from the Goldman Fund and additional support from the Society, the *Sustainable Seas Expeditions*, a five-year project of ocean exploration and conservation focusing on NOAA's national marine sanctuaries, was launched.

These 13 marine sanctuaries represent the best of the best of our nation's marine environments. Like our country's other crown jewels—the national parks—they are a legacy of our people and our ideals. They are the inheritance that we pass on to our children, and they to theirs. The sanctuaries contain some of the most important working parts of our ocean life support system—the sheer abundance of species, the processes that sustain us, the substances of tomorrow's medicines, and perhaps, the very secrets of life itself.

Ranging from American Samoa to New England, they include Pacific and Atlantic haunts of whales, sea lions, sharks, rays, and turtles; the overwhelmingly complex communities of coral reefs and lush kelp forests; the remains of numerous historically-valuable shipwrecks including the Civil War *Monitor* off North Carolina—and who knows what else.

Since April 1999, I have lead the expeditions to these protected areas, using DeepWorker 2000, a tiny one-person submersible capable of exploring 600 meters (2,000 feet) beneath the surface. This innovative submersible technology allows us to:

- ~ Conduct the first sustained piloted exploration of the sanctuary system to depths of 600 meters (2,000 feet).
- ~ Capture on tape and film the natural history of each sanctuary's algae, plants, and animals.
- ~ Pioneer new methods to monitor and document the long-term health of the marine sanctuaries.

Ultimately, with state-of-the-art exploration made possible by the DeepWorker, people will see images and video of the ocean's deep realms. From inside this small craft, DeepWorker pilots will experience and share a sense of the ocean from within, the way astronauts reported their view of Earth from space, and opened new horizons for us all. These small spacecraft-like submarines are magnets to children and veteran explorers alike. By seeing the DeepWorker subs up close at open houses and other public events, *Sustainable Seas Expeditions* will fuel imaginations and foster support for marine sanctuaries and conservation of our oceans.

The depths of our ocean are as uncharted as the vast interior of North America when President Thomas Jefferson sent Lewis and Clark to explore and record the unknown resources of the American West. *Sustainable Seas Expeditions* can produce significant discoveries and extraordinary educational experiences for millions through books, videos, and the Internet. In addition, the data gathered during the *Expeditions* will provide stronger foundations for marine research and conservation policies.

Whatever else we achieve, the ultimate success will be to dispel ignorance about the sea. Of all the ocean's problems, what we don't know poses the greatest threat. My goal is to push that frontier of ignorance further and deeper—and to return to the surface brimming with knowledge. With knowing comes caring, and with caring comes the hope that an ocean ethic will arise that will secure a sustainable future for ourselves, our children, and for the seas.

The success of the *Sustainable Seas Expeditions* depends on many fellow ocean explorers. To date, the Society and NOAA have been joined by the United States Navy, National Aeronautics and Space Administration (NASA), Monterey Bay Aquarium Research Institute (MBARI), Mote Marine Laboratory, Center for Marine Conservation, the National Science Teachers Association, and SeaWeb—and the list continues to grow. Join me and the 60 other DeepWorker pilots and scores of support technicians, vessel crew members, scientists, resource managers, and other *Sustainable Seas Expeditions* team members as this dream becomes reality.

Sustainable Seas Expeditions Web Sites

Orange sea star with brittle stars

© James Forte

Three web sites host information about *Sustainable Seas Expeditions*. The NOAA *Sustainable Seas Expeditions* site reports day-to-day activities by NOAA staff and scientists. The second site, National Geographic Society Blue Frontiers site, includes regular dispatches from Dr. Sylvia Earle. The third site, NOAA's National Marine Sanctuaries web site, contains a wealth of information about the sanctuaries and *Sustainable Seas*. These sites offer dynamic research tools that students and teachers can use to explore our nation's marine sanctuaries and follow *Sustainable Seas Expeditions* exploration and research as it happens. The major components of the three sites follow.

1. **The NOAA Sustainable Seas Expeditions Web Site** (http://sustainableseas.noaa.gov)

   This site hosts current day-to-day activities taking place during the *Sustainable Seas Expeditions* missions. It includes features such as:

   About Sustainable Seas—Describes the *Sustainable Seas Expeditions* program;

   Video Gallery—provides video and multimedia products produced during the *Sustainable Seas Expeditions;*

   Online Calendar—Provides schedules of events including *Expeditions* schedules, open houses, Sanctuary Summits, web chats, webcasts, and other opportunities at the sanctuaries;

   Weather—links to current weather conditions in the national marine sanctuaries;

   Mission Logs—Reports the ongoing story of *Sustainable Seas Expeditions* including events, discoveries, and adventures of the mission participants; background essays about each expedition; interviews with sanctuary managers; site characterizations of each sanctuary; and natural and cultural resources of the region.

2. **The National Geographic Society Blue Frontiers *Sustainable Seas Expeditions* Web site** (www.nationalgeographic.com/seas)

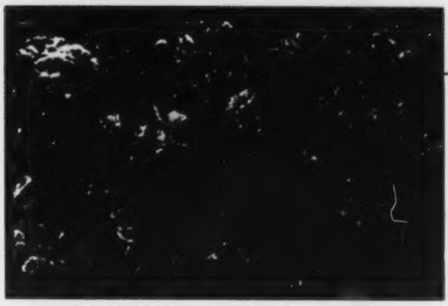
   The Blue Frontiers Website chronicles the *Sustainable Seas Expeditions*. This site includes:

   Explorer—Background information about expedition leader, Dr. Sylvia Earle;

   Expeditions—Overview of the *Sustainable Seas Expeditions* program and dispatches from the field;

   Equipment—Information about the DeepWorker submersible and other technologies used in the expeditions;

   Classroom Ideas—K-12 educational activities tailored around each *Sustainable Seas Expeditions* mission.



3. The National Marine Sanctuaries Web Site

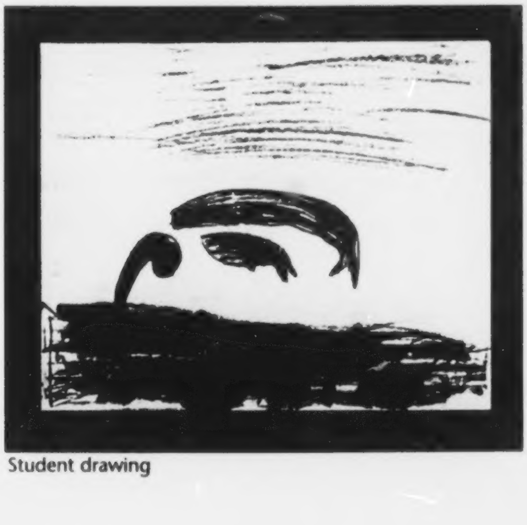
(http://www.sanctuaries.nos.noaa.gov)

This site provides comprehensive information about NOAA's national marine sanctuaries. It includes general information about the marine sanctuaries program, specific information about the sanctuaries, and links to each one. This site also includes an entire section on *Sustainable Seas Expeditions*. Features of this site include:

Science—Describes the research and monitoring efforts in the marine sanctuaries. A science feature changes bimonthly; Guest essays are written by scientists, resource managers and others about key marine science and conservation issues. A habitat feature describes a selected habitat found in each sanctuary;

Education—Provides an updated list of education and outreach activities at each sanctuary, descriptions of Sanctuary Summits and student projects, teacher workshops, sample activities, and an extensive resource and reference list;

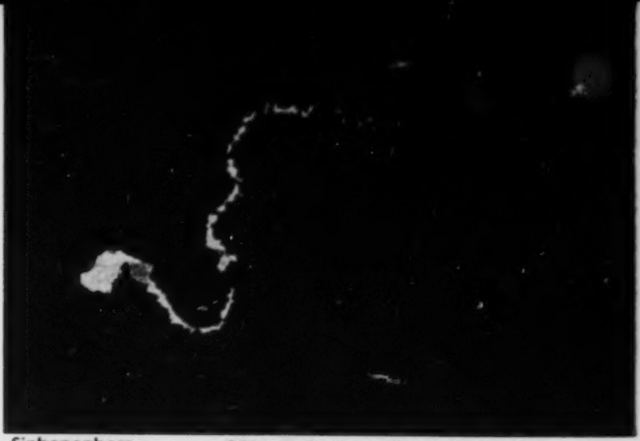
Photo Gallery—Displays stunning images that tell the story of each sanctuary. Images are categorized into The Living Sanctuary, Habitats, *Sustainable Seas Expeditions*, and People in the Sanctuary. The Gallery also includes a collection of student drawings, paintings and poems.



NATIONAL MARINE SANCTUARIES

Student drawing

Background Information



Siphonophore © Monterey Bay Aquarium Research Institute, 1991

The following articles provide background information that will be helpful when working with your students on the Investigations that follow. Each Investigation references one or more articles; some activities require students have their own copies of them to review.

NOAA's National Marine Sanctuaries

"Today, marine sanctuaries are places in the sea, as elusive as a sea breeze, as tangible as a singing whale. They are beautiful, or priceless, or rare bargains, or long-term assets, or fun, or all of these and more. Above all, sanctuaries are now, and with care will continue to be, 'special places.' Each of us can have the pleasure of defining what that means."

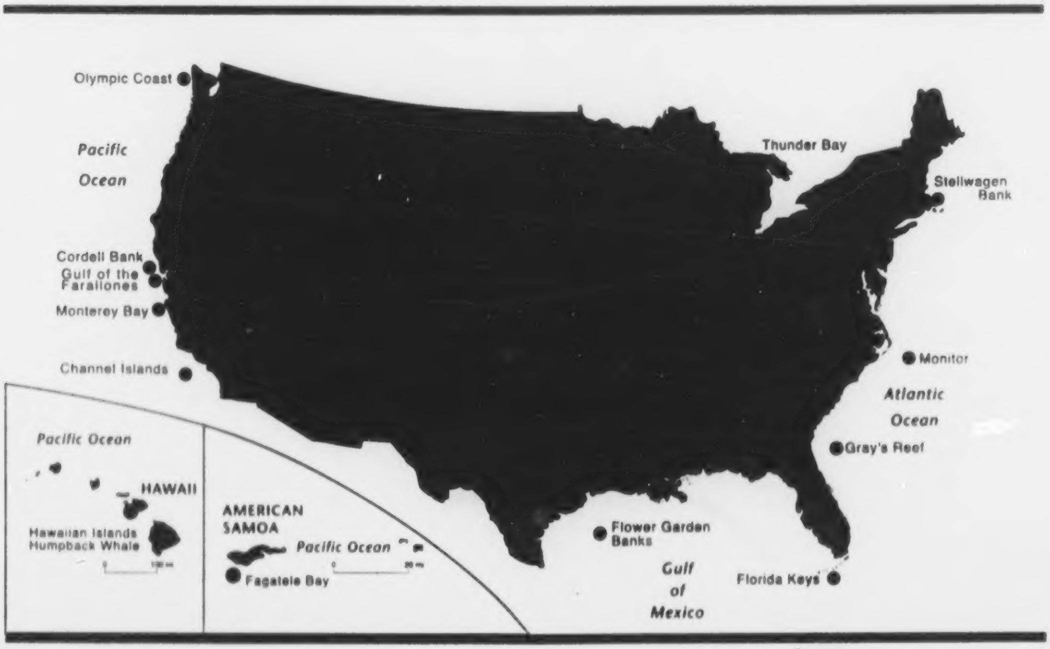
—Dr. Sylvia Earle

WHAT ARE MARINE SANCTUARIES?

In 1972, as Americans became more aware of the intrinsic ecological and cultural value of our coastal waters, Congress passed the Marine Protection, Research and Sanctuaries Act. This law authorizes the Secretary of Commerce to designate our most cherished marine waters as national marine sanctuaries, in order to protect and manage their priceless resources.

In the years since that time, 13 national marine sanctuaries have been created. They include nearshore coral reefs and open ocean, rich banks and submarine canyons, intertidal areas, and sheltered bays. National marine sanctuaries range in size from less than a neighborhood (Fagatele Bay, American Samoa—0.6 square kilometers or 0.25 square miles) to larger than the state of Connecticut (Monterey Bay—13,800 square kilometers or 5,328 square miles). Sanctuaries harbor a dazzling array of algae, plants, and animals. These protected waters provide a secure habitat for species close to extinction; and they protect historically significant shipwrecks and archaeological sites. They serve as natural classrooms for students of all ages and as living laboratories for scientists.

NOAA's National Marine Sanctuaries


Olympic Coast
Pacific Ocean
Cordell Bank
Gulf of the Farallones
Monterey Bay
Channel Islands
Thunder Bay
Stellwagen Bank
Monitor
Atlantic Ocean
Gray's Reef
Pacific Ocean
HAWAII
Hawaiian Islands Humpback Whale
AMERICAN SAMOA
Pacific Ocean
Fagatele Bay
Flower Garden Banks
Gulf of Mexico
Florida Keys

Sanctuaries are cherished recreational spots for diving, wilderness hiking, and sport-fishing. They also support valuable commercial industries such as marine transportation, fishing, and kelp harvesting. The perpetual challenge of managing these areas is maintaining the critical balance between environmental protection and economic growth.

SANCTUARIES FOR ALL

A sanctuary's true definition lies in the eyes of the beholder. To a scientist, a sanctuary is a natural laboratory. To a motel operator along the shore, it is a national commitment to keep the nature of the ocean healthy, and thus attractive to visitors. To schoolchildren of the area, a sanctuary is a special playground—a place to explore and discover. To environmental engineers charged with restoring damaged ecosystems, a sanctuary is a yardstick against which they can gauge "good health." Fishermen, however, might see the sanctuary as a threat to traditional freedoms, yet upon reflection, realize that it is the best hope for maintaining their way of life.

Trying to meet these needs leaves many unanswered questions. How large does a sanctuary need to be in order to protect the ecosystems that lie within? How much pressure can an ecosystem sustain from activities bordering its boundaries? How many fish can we take while ensuring a healthy population for the long term?

National marine sanctuaries represent our riches as a nation. They are treasures that belong to every citizen, and to every generation of citizens to come. We have the right to enjoy them and—just as importantly—the responsibility to sustain them for the long-term.

© W. B. Evans

Nudibranch

Exploring—For Answers

EXPLORERS FROM THE BEGINNING

We are all explorers. Our first journeys begin before we can move, when, as infants, our field of vision begins to take in the shapes and forms around us, patterns of light and dark on the walls, the features of our mother and father's faces. Gradually, our senses sharpen and we acquire halting mobility, the ability to crawl to the grass's edge, to toddle toward a puddle, to enter a nearby wood. As our means to travel become more sophisticated, we venture further abroad—a bicycle, we discover, carries us for kilometers; a city bus, across town; the family station wagon, across the state; a backpack, into the wilderness. As we grow physically in our capability to go places, our minds begin journeying too.

Gradually, we come to know the lore of travel, of exploration. We learn about the great explorers—Winken, Blinken and Nod in their shoe; Huckleberry Finn on his Mississippi River; Odysseus over the "wine-dark seas"; Marco Polo to the palaces of Cathay; Lewis and Clark across the distant Rockies; Neil Armstrong to the moon. In turn, we become them. We listen raptly to their exploits, pore over their journals, memorize their footsteps—and missteps—challenge ourselves to meet their challenges and grow the personal boldness it takes to enter into explorers' lives.

TIMES CHANGE

All too soon, however, the universal explorer in most of us begins to stay at home. We turn our attention to practical matters; perhaps we become satisfied with that at hand. Our concentration narrows and we master finer skills. We learn our lessons and come to value personal safety above risk, security above uncertainty. Internally, we map a landscape of the familiar and live most of our lives within it.

The familiar is not for everyone. There is a certain lure that motivates explorers beyond. Sir George Mallory, the British mountaineer who explored—and vanished—in the Himalayas, was motivated to climb Mt. Everest "because it's there." For others, needs emerge greater than their own—something honorable to their nation, or to humanity as a whole. As we close the twentieth century, it is clear that the world's oceans—explored and charted for hundreds of years—require a new kind of exploration if they are to survive as our planetary life-support systems.

EXPLORING THE SEAS

This new exploration is not about conquest of territory, or sovereignty over the ocean's wealth. It is the conquest over our ignorance of ocean ecosystems, in particular, the deeper realms of our most precious marine areas, the national marine sanctuaries. *Sustainable Seas Expeditions*, led by Dr. Sylvia Earle, continues the legacy of ocean exploration of Alexander the Great (reported to be the first person to descend into the sea to observe fish), of British scientists aboard the H.M.S *Challenger* (who discovered 4,417 new species in the 1870s), and Jacques Piccard (who manned the Trieste 10,912 meters, or 35,800 feet, deep in the Pacific in 1960).

The three-dimensional world under water represents one of the most challenging environments of all in which to work. Although we have adapted to nearly all conditions on Earth's surface, extreme cold, crushing pressure, and darkness deprive us of access to what amounts to nearly 90 percent of our biosphere by volume. Even with technology, we gain mere glimpses of this interior living space on our planet. We snatch samples with collecting bottles or dredges suspended on cables; we probe with sound, studying patterns in the echoes; we pilot robot submarines with cameras. We skim the ocean's upper surface with scuba systems. Occasionally, we deploy the several dozens of submersibles in existence for the purpose of going and looking, in person.

We have explored less than one percent of the deep ocean floor and know less about many aspects of geophysical systems in the ocean than we know about the weather on Mars. This is particularly true in the dimly lit midwaters (below 100 meters, or 330 feet) and in the ocean abyss. We are only beginning to understand the geologic processes forming seafloor at the mid-ocean ridges, and the communities of organisms that feed solely on chemicals produced in volcanic eruptions or gas seeps. These features are pinpoints in an area covering 70 percent of our planet. Our experience studying them close at hand would be equivalent to having spent several hundred hours visiting five or six active volcanoes scattered about the continents.

© Kip Evans

Diver in kelp forest

THERE IS STILL MORE TO LEARN

Our explorations of the oceans' living systems are in their infancy. Of all the animal kingdom's phyla, many describe residents of the ocean. We know very little of this dazzling array of living things. Life evolved in the sea and few lifeforms were able to survive without water supporting their bodies. The sea continues to be our life support system and our own health is connected to it.

The species we know best are those we take most freely and which have the greatest utility for us as food, fertilizer, or other material use. In most cases, that knowledge is driven only by scarcity imposed by overuse. We take the time to understand only after we have brought a stock or species to the brink of extinction. What do we know of most marine invertebrates? What are the key species that bind deep ocean communities together? What are the pieces that simply cannot be removed without system collapse? These are questions with embarrassingly few complete answers.

FUTURE OF THE SEA

For most of our history, life in the oceans has been out of sight and out of mind. Yet dangerous signs of damage are now plainly visible. Biodiversity in our oceans is threatened; habitats are being altered; our actions on land are making the seas a sink for toxic chemicals. We need to explore the oceans in order to understand the intricate connections between our actions and the oceans' health. We need windows into this foreign world, observers who can visit and record, discover and monitor; and watchers who can go and return, sharing the results of their explorations with the vast majority, who will never have such an experience.

Our best explorers have been those who purposely brought all of us along with them. Naturalist William Beebe, plumbing the ocean depths off Bermuda in 1934 in his bathysphere, broadcast live via the NBC Radio Network and followed with detailed articles in *National Geographic* magazine. The television era allowed millions to be with Astronaut John Glenn as he circled the Earth three times. The tickertape parade he enjoyed after that historic space exploration was as much a spontaneous celebration of our collective journey around the planet as it was the recognition of a new explorer-hero.

AN OPPORTUNITY TODAY

The *Sustainable Seas Expeditions* are your explorations—of your national marine sanctuaries. The inventors, technicians, researchers, ships' crews, pilots, and support staff who comprise the *Sustainable Seas* team are the tools by which you, too, embark on this historic exploration project.

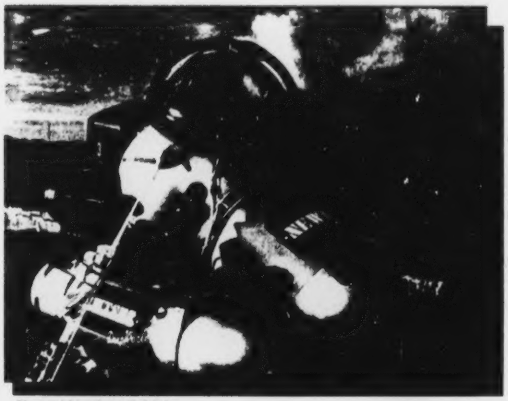
Meet DeepWorker

AN OCEAN EXPLORER'S DREAM

DeepWorker 2000 is a one-person submersible about the size of a small car. This remarkable vehicle can dive to a depth of 600 meters (2,000 feet) and provide life-sustaining oxygen for its pilot for up to 80 hours (in an emergency—normal operations rarely exceed 12 hours). Without tethers or connecting lines to its support ship, DeepWorker gives its pilot amazing mobility and the gift of time—a precious commodity for humans in the underwater environment.

Because DeepWorker is a directly operated vehicle—or DOV—it moves independently of its surface support ship. The sub is driven by a trained pilot who may be a scientist, technician, explorer, or even a journalist, teacher, or poet. The sub's simple, yet sophisticated technology means that the pilot and the passenger are combined—one person can pilot the craft and still carry out observations and scientific experiments. Eliminating the second occupant from the sub reduces its weight, complexity, and the expense of operation.

DeepWorker's small size and light weight make it more mobile than most other submersibles. Measuring just over two meters long (eight feet), it fits easily on a truck or trailer for traveling overland. At the dock, it can be loaded on a ship with a relatively small crane; and at the dive site, the 1,600 kilogram (1.6-ton) sub can be launched with many types of common equipment. Older, heavier systems require dedicated launch machinery and usually dive only from a specially-constructed support ship. DeepWorker can be supported by many ships.



Kip Evans, © National Geographic Society

DeepWorker 2000

A TOUGH PLACE TO WORK

The physical environment under water requires any submersible vehicle to have five important features: a hull that resists collapse; a propulsion system for mobility; a ballast system to control ascent and descent; a life-support system for its occupant or occupants; and navigation and communication systems for orientation in the darkness and staying in touch with the surface.

PRESSURE HULL

The hull, or external structure, of a deep diving submersible must be built to withstand incredible pressures. For every 10 meters (33 feet) a sub descends into the ocean, another 6.6 kilograms (14.7 pounds) of pressure is added to every six square centimeters (one square inch) of the capsule. At 600 meters (2,000 feet), the depth reachable by DeepWorker, the pressure is over 404 kilograms per six square centimeters (890 pounds per square inch). In order to resist collapsing under pressure, most submersibles are spherical. Forces applied to a sphere are equally distributed throughout its circumference, giving this shape incredible strength.

Most subs, including deep-diving craft like DeepWorker, Alvin, and Deep Flight, are not perfect spheres. If a portion of the sphere must be removed to accommodate other design features, such as battery pods or to create space for a pilot's comfort (like a leg-tube, or viewing dome) the strength can be replaced by inserting a thick, strong ring around the hole and attaching a cylinder or semi-spherical shape. Like spheres, cylinders resist pressure by distributing forces throughout the circumference. However, they are not as strong as spheres.

DeepWorker actually consists of several spherical, cylindrical, and semi-spherical pressure hulls. The main hull is a sphere (in which the pilot sits) with an attached cylinder on the bottom (for the pilot's legs) and an acrylic dome on top for viewing. The two battery pods (lower starboard and port sides), the junction box (lower rear), and the oxygen and air tanks (mounted on the back in a float pack) are cylinders. The acrylic dome also serves as a hatch to enter and exit the sub.

PROPULSION

DeepWorker is powered by two battery pods, each containing 10 high-ampere, deep-cycle batteries (similar to the ones used in motor homes). The sub can reach speeds of up to three knots. The batteries power two horizontal thrusters (for forward and reverse movement) and two vertical thrusters (for lateral movement), which are controlled by foot pedals inside the sub. To operate the sub, a pilot pushes on the pedals: the right pedal moves the craft in the horizontal direction. Toe down is forward. Heel down is reverse. A twist to the right turns you right and to the left turns you left. The left foot moves the craft down (toe down) or up (toe up). A twist to the right makes the sub walk sideways ("crabbing") to the right; twist to the left and it crabs left. Crabbing is like turning all four tires on a car 90 degrees—great for parallel parking or for moving sideways to examine the face of an underwater cliff.

BALLAST

In order to regulate its position up and down in the water and to remain at a certain depth without rising or sinking, DeepWorker uses two forms of ballast systems—"soft" ballast and "hard" ballast.

Many submersibles use what is called a "soft" ballast system in which compressed air is released into an external tank to increase the craft's buoyancy and bring it back to the surface. At deep depths, air becomes so compressed by water pressure that it can take an entire tank to lift the sub off the bottom. In these systems, such as the Deep-Rover submersible, pilots must limit their up and down movements at depth to conserve air for the final ascent.

DeepWorker uses soft ballast together with another ballast system known as "hard" ballast. In the hard ballast system, colored water is contained within an enclosed small bladder outside the sub. After the pilot dumps all the air from the soft ballast tank in order to lower the sub below the surface, the sub remains slightly buoyant. To sink, the pilot opens a valve to allow a small amount of the colored water into the sub, which adds weight. The water begins to fill a tank in the pilot's seat, and the sub descends. When the sub is neutrally buoyant (neither sinking nor rising), the pilot shuts off the valve. This ingenious design allows the pilot to remain neutrally buoyant at any depth. Pilots can tell when they are neutrally buoyant by looking at minute particles drifting outside in the water column. When the sub hangs motionless in relation to the tiny organisms and debris that make up the "marine snow," the sub is neutrally buoyant.

LIFE SUPPORT

Water is essential for life. Yet, for many animals including humans, it is extremely toxic to breathe. Thus, the greatest limit to our ability to work in the ocean is the fact that we can't obtain enough oxygen from water to stay alive. Fortunately, inventors, engineers, and adventurers have figured out how to get oxygen into our lungs, and how to remove poisonous carbon dioxide from the air we exhale—even when we are on the bottom of the sea. Life support systems aboard DeepWorker include two separate oxygen systems and two carbon dioxide removal systems—one of each for normal use, the other as backup. These life support systems create a normal breathing environment inside the sub—at pressures comparable to your living room.

DeepWorker carries two oxygen cylinders outside of its main pressure hull and two mechanical controllers inside the hull where the percent of oxygen is monitored electronically. High pressure tubes and valves carry the oxygen in special "through-hull" fittings into the main hull. A special regulator reduces the flow of oxygen to a trickle—about equal to the amount the pilot consumes in non-aerobic activity. As the pilot breathes in, oxygen goes into the lungs, replaced by oxygen regulated to trickle into the cabin. As the pilot exhales into the cabin, a small fan forces the air through a chemical filter, called a scrubber, removing dangerous carbon dioxide. Pilots frequently monitor the oxygen content of the cabin (it should be 20.8 percent), the pressure of the oxygen entering the hull, the pressure of the oxygen in the regulator, and the operation of the scrubber fan. In event of a failure of the primary system, the pilot simply switches to the backup.

Oxygen bottles and scrubber chemicals are changed after every dive, but DeepWorker's life support systems could provide nearly 80 hours of time under water if necessary.

NAVIGATION AND COMMUNICATION

On board, an integrated navigation system constantly sends signals to the support ship on the surface, tracking DeepWorker's whereabouts. Pilots overcome the natural limits of seeing long distances under water by using sonar—computer-sorted echoes that actually create visual images of the underwater landscape from sound. Powerful headlights illuminate the depths close to the sub. Other instruments determine the sub's depth and altitude off the bottom. To communicate with the mother ship, two communication systems are used: VHF radio while DeepWorker is on the surface; and a thru-water system that sends sound waves through the water to receivers on the ship above. Pilots and the surface support teams communicate regularly to confirm relative locations and the status of DeepWorker's life support and electrical systems.

DEEPWORKER'S TOOLS

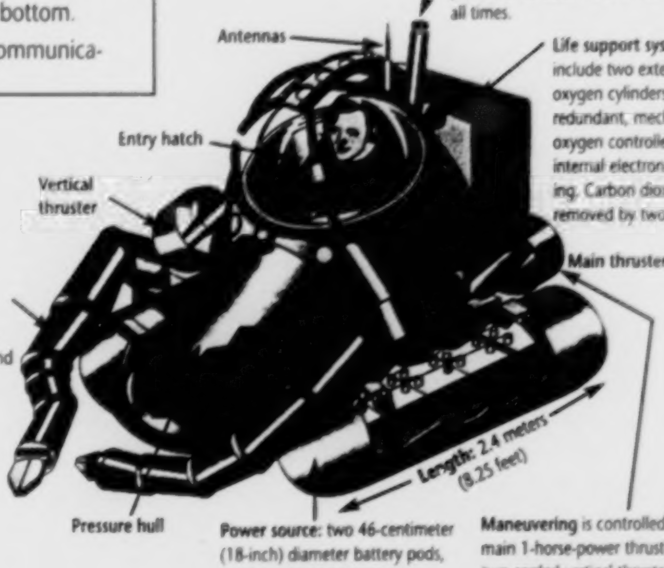
In addition to DeepWorker's design and life support systems, the sub also uses specialized equipment to document marine life, habitat characteristics, and to monitor physical factors such as temperature, the amount of light penetrating the sea, and water quality. Equipment for collecting this data includes:

- cameras (video and still);
- external lights that can be turned on and off;
- a water quality data recorder that continuously records conductivity (to determine salinity), temperature, and depth;
- manipulator arms capable of reaching to 3.6 meters (12 feet);
- cable cutters on the arms to cut free from entanglement;
- suction samplers to collect sea water and animals;
- core samplers; and
- sample baskets for transporting organisms.

DeepWorker 2000

SPECIFICATIONS
Weight in air: 1,600 kilograms (1.6 tons)
Operating depth: 600 meters (2,000 feet)
Payload: 136 kilograms (300 pounds), including pilot
Life Support: 80 hours
Speed: 4 knots maximum
Crew: 1 pilot

COMMUNICATION SYSTEMS include a modified Imaginex sonar, which allows standard scanning and ultra-high resolution for short range. Ocean sounds are recorded with a directional hydrophone. Video cameras allow the pilot to record the dive. VHF and thru-water communications allow contact with surface support personnel.



Acoustic tracking system permits surface personnel to determine location of sub at all times.

Life support systems include two external oxygen cylinders and two redundant, mechanical oxygen controllers with internal electronic monitoring. Carbon dioxide is removed by two scrubbers.

The **robotic arms** are hydraulic-powered manipulators that can extend 3.6 meters (12 feet).

Power source: two 46-centimeter (18-inch) diameter battery pods, each containing 10 high-amp, deep-cycle batteries.

Maneuvering is controlled by two main 1-horse-power thrusters plus two angled vertical thrusters for lateral movement. A 3-cubic-meter (100-cubic-foot) ballast air tank provides additional depth control.

Sustainable Seas Expeditions Research

Over a five-year period, the *Sustainable Seas Expeditions* will provide a unique opportunity to seek greater insight into what makes some of our nation's most important natural resources tick. *Sustainable Seas Expeditions* will use new submersible technology to undertake deep exploration of the nation's national marine sanctuaries to depths up to 600 meters (2,000 feet). The *Expeditions* will photodocument the natural history of each sanctuary's algae, plants, animals, and cultural resources; build on existing site characterizations; and in some cases, produce the best information to date on these protected areas.

Over the course of the project, *Sustainable Seas Expeditions* will help establish permanent monitoring field stations within the sanctuaries, and conduct other underwater investigations. These projects are critical to effective marine protection and conservation.

"*Sustainable Seas Expeditions* has the potential to produce stunning scientific discoveries and extraordinary educational experiences for millions of people," said John Fahey, president and CEO of the National Geographic Society. "The data we gather will provide stronger foundations for marine research and for more sound marine conservation policies. Through new knowledge, we have the opportunity to create a 'sea change' in how Americans perceive—and care about—their coastal and ocean resources."

Putting *Sustainable Seas Expeditions* research into perspective requires understanding three important goals of the research projects:

- Understanding what is there by systematic exploration, mapping, and species inventories—a process known as site characterization;
- Looking at a place over time and making spatial comparisons to understand what changes are taking place, and why—a process known as monitoring;
- Assessing the potential of new tools, like DeepWorker, in research and management of marine sanctuaries.

SITE CHARACTERIZATION

In order to understand any natural environment and make wise decisions that lead to its protection, sanctuary managers need several critical pieces of information. These include knowing what is there (the "parts" of an ecosystem such as the algae, plants, animals, water temperature, and so on), the ecosystem's condition in the past—or at least its condition now—and enough understanding of how the ecosystem works to predict future conditions given certain variables. These are all elements of what sanctuary managers call "site characterizations." Many of the sanctuaries will be conducting site characterizations as part of their *Sustainable Seas Expeditions* projects.

Site characterizations provide managers with information that helps them make effective decisions when it comes to determining human activities in protected areas; setting agendas for research, monitoring, education, outreach, and enforcement programs; and using the most appropriate methods to restore an area, should that be necessary.

Site characterizations are detailed reports that contain information on an area's biological and physical environments, cultural history, and human use patterns. They chronicle the history of discovery and use, the record of scientific investigations, the pressures being placed on natural and cultural resources, and the nature of attempts to protect the resources. Properly done, they are complete sources of current information for an area of particular interest.

When conducting site characterizations, there are a number of ways scientists document the presence and abundance of species relative to the environment's physical factors. One method is conducting vertical and horizontal transects.

Vertical transects in the sea are useful to define the ocean's layering system of physical and biological parts. Imagine dropping a line from one point in the water column down to another. Physical factors are then observed and recorded at various points along this line, or transect. Increments along the transect are usually evenly spaced, and when combined with similar transects in other locations, may reveal changes taking place due to water currents, upwelling, and other phenomena.

Horizontal transects are conducted similarly. These are most often used along the seafloor or at a particular depth. For instance, a horizontal transect at a depth of 600 meters might look for distribution of fish species close to a canyon wall compared to fish species at the same depth further from the wall.

Given the constraints of time and money, these techniques provide researchers with methods to construct models of an ecosystem while only studying small portions of it. The models help us understand how an ecosystem functions. They may describe the flow of energy through a system or they may allow us to predict the effects of natural or human-caused events on an ecosystem.

MONITORING

Monitoring programs are designed to detect changes spatially and over time—changes in physical conditions, changes in distribution or abundance of organisms, or changes caused by human actions and natural events.

Physical factors such as temperature and salinity measured as baseline data can form the foundation of a monitoring program. So can the presence or absence of a species, or age groups of a single species or entire groups of species. Habitats can be monitored to observe changes in structure, such as physical disturbance. In a monitoring project, observations are made or samples are taken—like "snapshots" of the habitat—on a regular basis, at various intervals depending on the type of information needed. Periodic reports of data compare snapshots against each other and against the baseline data. This information helps resource managers evaluate trends (systematic changes over time) or perturbations (sudden changes).

Kevin Raskoff © MBARI 1998

Deepwater jelly

Although the causes of these changes may not be apparent as a result of monitoring, they alert managers and suggest ways of studying, in closer detail, the causes of change.

ASSESSING RESEARCH TOOLS

In addition to supporting sanctuary site characterization and monitoring needs, the five-year *Sustainable Seas Expeditions* project and the newly developed submersible technology offer the scientific community a chance to evaluate the use of the new one-person sub. Nuytco Research Ltd. developed the lightweight DeepWorker submersible (1,600 kilograms) to operate almost as easily as remotely operated vehicles (ROVs), which are unmanned, underwater robots often used at these depths. As Nuytco founder Phil Nuytten puts it, the concept was to "take the ROV operator out of the control shack and put him in the ROV." With the potential of new discoveries beckoning and a new national commitment to assess and understand our ocean planet, the *Sustainable Seas Expeditions* promise new knowledge and new ways to gather knowledge.

© Wolcott Henry

Diver explores coral formation

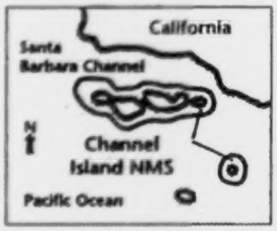
Harbor seal © W. E. Townsend

National Marine Sanctuary Sites

A Look at the Sanctuaries

The nation's sanctuaries encompass sites that are either biologically, culturally, recreationally, aesthetically, or historically significant. In some ways similar to the national parks on land, each one has its own character, and each sanctuary is many things to many people, adding to their charm.

Channel Islands California



The waters that swirl around the five islands contained within NOAA's Channel Islands National Marine Sanctuary combine warm and cool currents to create an exceptional breeding ground for many species of algae and animals. Nearby forests of giant kelp provide a nutrient-rich environment for teeming populations of fish and invertebrates. Every year, over 27 species of whales and dolphins visit or inhabit the sanctuary including the rare blue, humpback, and sei whales. Seabird colonies and pinniped rookeries flourish on the islands; while overhead, Brown Pelicans and Western Gulls search the water for food.

Habitats

Kelp forests
Seagrass meadows
Rocky shores
Pelagic, open ocean
Sandy beaches
Deep rocky reefs

© Thomas M. Carey

Garibaldi in kelp forest

Key Species

California sea lion
Elephant seal
Harbor seal
Blue whale
Gray whale
Dolphins
Blue shark
Brown Pelican
Western Gull
Abalone
Garibaldi
Rockfish

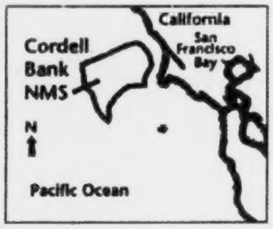
Cultural Resources

Chumash Indian artifacts

Protected Area

4,294 square kilometers (1,658 square miles)

Cordell Bank California



A region of astonishing productivity, NOAA's Cordell Bank

National Marine Sanctuary surrounds a 6-by-14-kilometer (4-by-9-mile) submerged granite island on the very edge of the continental shelf. Lying just off the northern California coast, the Bank rises to within 35 meters (115 feet) of the sea surface with depths of 1,830 meters (6,000 feet) only a few kilometers away. The prevailing California Current flows southward along the coast and the upwelling of nutrient-rich, deep ocean waters stimulates the growth of organisms at all levels of the marine food web. Many marine mammals and seabirds rely on this area as their feeding ground.

Habitats

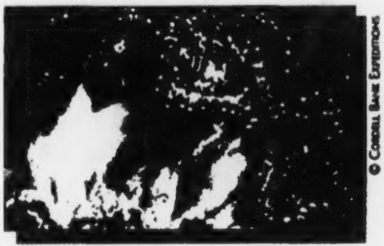
Rocky subtidal
Pelagic, open ocean
Soft sediment continental shelf and slope
Submerged island

Key Species

Krill	Blue whale
Pacific salmon	Hydrocoral
Rockfish	Albatross
Humpback whale	Shearwater

Protected Area

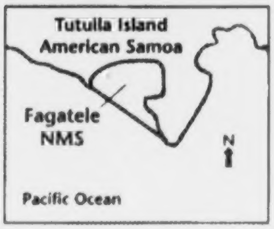
1,362 square kilometers (526 square miles)



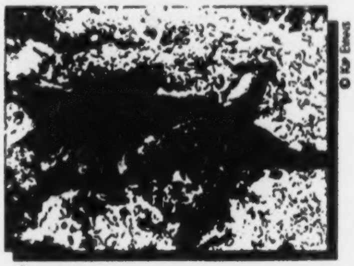
© Cordell Bank Expeditions

Strawberry anemone

Fagatele Bay American Samoa



Located 14 degrees south of the equator, NOAA's Fagatele Bay comprises a fringing coral reef ecosystem nestled within an eroded volcanic crater on the island of Tutuila. Nearly 200 species of coral are recovering from a devastating crown-of-thorns starfish attack in the late 1970s which destroyed over 90 percent of the corals. Since then, new growth has been compromised by two hurricanes, several tropical storms, and coral bleaching. This cycle of growth and destruction is typical of tropical marine ecosystems.



© Kip Evans

Sea stars

Habitat

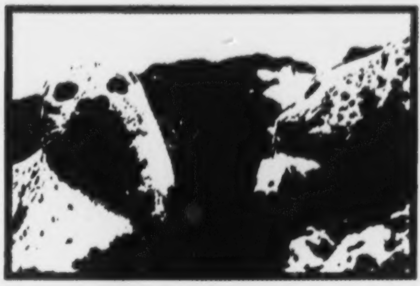
Tropical coral reef

Key Species

Surgeon fish	Hawksbill turtle
Crown-of-thorns sea star	Giant clam
Blacktip reef shark	Parrotfish

Cultural Resources

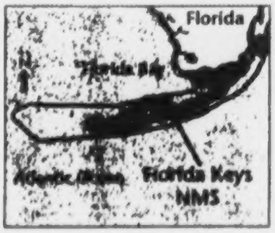
3,000-plus-year-old thriving Polynesian culture originated in Samoa



Protected Area

0.6 square kilometers (0.25 square miles)

Florida Keys Florida



The Florida Keys marine ecosystem supports one of the most diverse arrays of underwater algae, plants, and animals in North America. Although the Keys are best known for coral reefs, there are many other significant interconnecting and interdependent habitats. These include fringing mangroves, seagrass meadows, hardbottom regions, patch reefs, and bank reefs. This complex marine ecosystem is the foundation for the commercial fishing and tourism-based economies that are so important to Florida.

Habitats

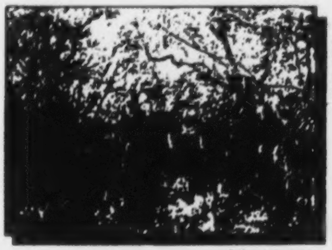
Coral reefs
Patch and bank reefs
Mangrove-fringed shorelines and islands
Sand flats
Seagrass meadows

Key Species

Brain and star coral
Sea fan
Loggerhead sponge
Spiny lobster
Stone crab
Grouper
Turtle grass
Angelfish
Tarpon

Cultural Resources

Historic shipwrecks
Historic lighthouses

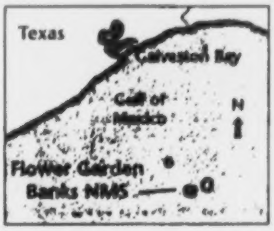

Heather Dine

Mangroves

Protected Area

9,515 square kilometers (3,674 square miles)

Flower Garden Banks Texas/ Louisiana



One hundred sixty-one kilometers (100 miles) off the coasts of Texas and Louisiana, a trio of underwater salt domes emerge from the depths of the Gulf of Mexico. Lush gardens of coral blanket the domes. This premiere diving destination harbors the northern-most coral reefs in the United States and serves as a regional reservoir of shallow-water Caribbean reef fishes and invertebrates. For a few nights each August, in association with the full moon, the corals undergo a mass spawning, releasing billions of gametes into the water in a spectacular display.

Habitats

Coral reefs
Pelagic, open ocean
Algal-sponge communities
Sand flats
Artificial reef
Brine seep

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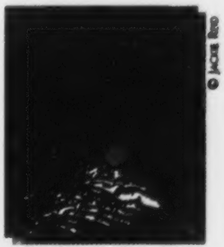
Key Species

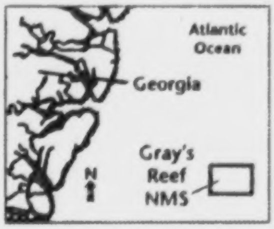
Star coral
Hammerhead shark
Brain coral
Loggerhead turtle
Manta ray


© JACKIE REID
Coral spawning

Protected Area

145 square kilometers (56 square miles)

Gray's Reef
Georgia

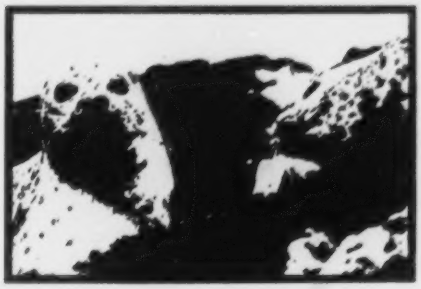


Just off the coast of Georgia, in waters 20 meters (66 feet) deep, lies one of the largest near-shore sandstone reefs in the southeastern United States. The area earned sanctuary designation in 1981, and was recognized as an international Biosphere Reserve by UNESCO in 1986. NOAA's Gray's Reef National Marine Sanctuary consists of sand-stone outcroppings and ledges up to three meters in height, with sandy, flat-bottomed troughs between. Because of the diversity of marine life, Gray's Reef is one of the most popular sport fishing and diving destinations along the Georgia coast.

Habitats

Calcareous sandstone
Sand bottom communities
Tropical/temperate reef

© MATT GALLIGAN
Greater amberjack



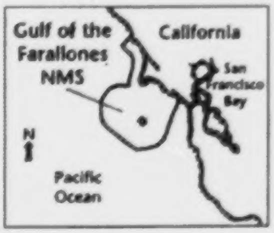
Key Species

Northern right whale	Angelfish
Loggerhead turtle	Barrel sponge
Grouper	Ivory bush coral
Black sea bass	Sea whips

Protected Area

60 square kilometers (23 square miles)

Gulf of the Farallones
California



NOAA's Gulf of the Farallones National Marine Sanctuary includes nurseries and spawning grounds for commercially valuable species, at least 33 species of marine mammals, and 15 species of breeding seabirds. One-quarter of California's harbor seals breed within the sanctuary. The Farallon Islands are home to the largest concentration of breeding seabirds in the continental United States. The sanctuary boundaries include the coastline up to mean high tide, protecting a number of accessible lagoons, estuaries, bays, and beaches for the public.

Habitats

Sandy beaches
Rocky shores
Mud and tidal flats
Rocky subtidal
Deep benthos, continental shelf and slope
Pelagic, open ocean
Esteros
Salt marsh

Key Species

Dungeness crab
Common Murre
Gray whale
Ashy Storm-petrel
Steller sea lion
White shark
Short-bellied rockfish
Pacific sardine

© W. E. Evans

California sea lion

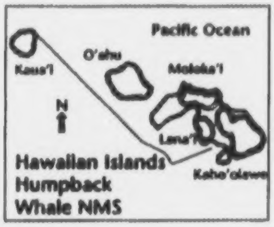
Cultural Resources

Shipwrecks
Fossil beds

Protected Area

3,250 square kilometers (1,255 square miles)

Hawaiian Islands Humpback Whale Hawaii



The shallow, warm waters surrounding the main Hawaiian Islands constitute one of the world's most important humpback whale habitats. Scientists estimate that two-thirds of the entire North Pacific humpback whale population migrates to Hawaiian waters each winter to engage in breeding, calving, and nursing activities. The continued protection of humpback whales and their habitat is crucial to the long-term recovery of this endangered species.

Habitats

Humpback whale breeding, calving, and nursing grounds
Coral reefs
Sandy beaches

© Dave Salden

Humpback whale

Key Species

Humpback whale
Pilot whale
Hawaiian monk seal
Spinner dolphin
Green sea turtle
Trigger fish
Cauliflower coral
Limu

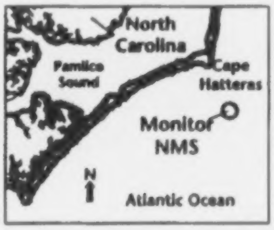
Cultural Resources

Native Hawaiian practices
Native Hawaiian fish pond
Archaeological sites
Historic shipwrecks

Protected Area

3,367 square miles (1,300 square miles)

Monitor
North Carolina



On January 30, 1975, the nation designated its first national marine sanctuary. The site was the wreck of the USS *Monitor*, a Civil War vessel that lies 26 kilometers (16 miles) southeast of Cape Hatteras, North Carolina. The *Monitor* was the prototype for a class of U.S. Civil War ironclad, turreted warships that significantly altered both naval technology and marine architecture in the nineteenth century. The *Monitor* was constructed in a mere 110 days. At 70 meters (230 feet) deep, it is beyond reach for most people to visit. However, this artificial reef provides a home for many animals, including sea anemones, sea urchins, and a host of fishes.

Habitats

Pelagic,
open ocean
Artificial reef

© [illegible] Monitor Expeditions

Amberjacks living in the wreck

Key Species

Amberjack
Black sea bass
Red barbier
Scad
Sea anemones
Dolphin
Sand tiger shark
Sea urchins

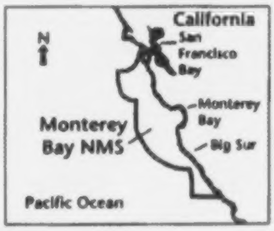
Cultural Resources

The remains of the Civil War ironclad USS *Monitor*

Protected Area

2.6 square kilometers (1 square mile)

Monterey Bay
California



Monterey Bay, the largest of NOAA's marine sanctuaries, hosts a rich array of habitats. Within its boundaries lie rugged rocky shores, lush kelp forests, and one of the deepest underwater canyons on the west coast. The canyon cuts more than 3,500 meters (2 miles) deep and reaches nearly 100 kilometers (60 miles) out to sea. Sanctuary habitats abound with life, from tiny plankton to huge blue whales. With its great diversity of habitats and life, the sanctuary is a national focus for marine research and education programs.

Habitats

Sandy beaches
Rocky shores
Kelp forests
Submarine canyon
Pelagic, open ocean
Wetlands

Key Species

Sea otter
Gray whale
Market squid
Brown Pelican
Rockfish
Giant kelp

Cultural Resources

Indian midden sites
Naval airship USS *Macon*

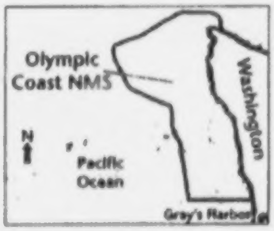
Protected Area

13,798 square kilometers (5,328 square miles)

National Marine Sanctuaries

Monterey coastline

Olympic Coast Washington



NOAA's Olympic Coast National Marine Sanctuary spans 8,570 square kilometers (3,310 square miles) of marine waters off the rugged Olympic Peninsula coastline. The sanctuary averages approximately 56 kilometers (35 miles) seaward, covering much of the continental shelf and protecting habitat for one of the most diverse marine mammal faunas in North America. It is also a critical link in the Pacific Flyway. The sanctuary boasts a rich mix of cultures, preserved in contemporary lives of members of the Quinault, Hoh, Quileute, and Makah tribes.

Habitats

Rocky and sandy shores
Seastacks and islands
Pelagic, open ocean
Kelp forests

Olympic Coast NMS

Tskawahyah Island

Key Species

Tufted Puffin
Bald Eagle
Northern sea otter
Gray whale
Humpback whale
Pacific salmon
Dolphin

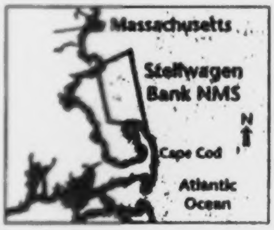
Cultural Resources

Native American petroglyphs and villages
Historic lighthouses
Shipwrecks

Protected Area

8,572 square kilometers (3,310 square miles)

Stellwagen Bank Massachusetts



Formed by the retreat of glaciers from the last Ice Age, Stellwagen Bank consists primarily of coarse sand and gravel. Its position at the mouth of Massachusetts Bay forces an upwelling of nutrient-rich water from the Gulf of Maine over the bank—leading to high productivity and a multi-layered food web with species ranging from single-celled phytoplankton to the great whales.

Habitats

Sand and gravel bank
Muddy basins
Boulder fields
Rocky ledges

Key Species

Northern right whale
Humpback whale
White-sided dolphin
Storm Petrel
Northern Gannet
Bluefin tuna
Atlantic cod
Winter flounder
Sea scallop
Northern lobster

Cultural Resources

1898 wreck of the steamer *Portland*

Middle Ground fishing area

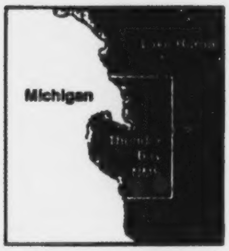
© Norm Despres

Wolffish

Protected Area

2,181 square kilometers (842 square miles)

Thunder Bay Michigan



Thunder Bay National Marine Sanctuary and Underwater Preserve is the nation's newest and thirteenth marine sanctuary. More than a century of Great Lakes maritime heritage lies below the water of Lake Huron in Thunder Bay. From wooden schooners to steel-hulled steamers, a rich array of artifacts from nineteenth century travel and commerce still remain on Lake Huron's floor. This sanctuary and underwater preserve protects the nationally significant collection of approximately 116 shipwrecks.

Cultural Resources

Historically Significant Shipwrecks:
Havre
Kyle Spangler
James Mowatt
Grecian
H. Hubbard
John F. Warner
New Orleans
Isaac M. Scott

Lighthouses:
Sturgeon Point
Middle Island
Thunder Bay Island
Presque Isle

Protected Area

1,160 square kilometers (448 square miles)

Institute for Great Lakes Research, Bowling Green State University

Grecian

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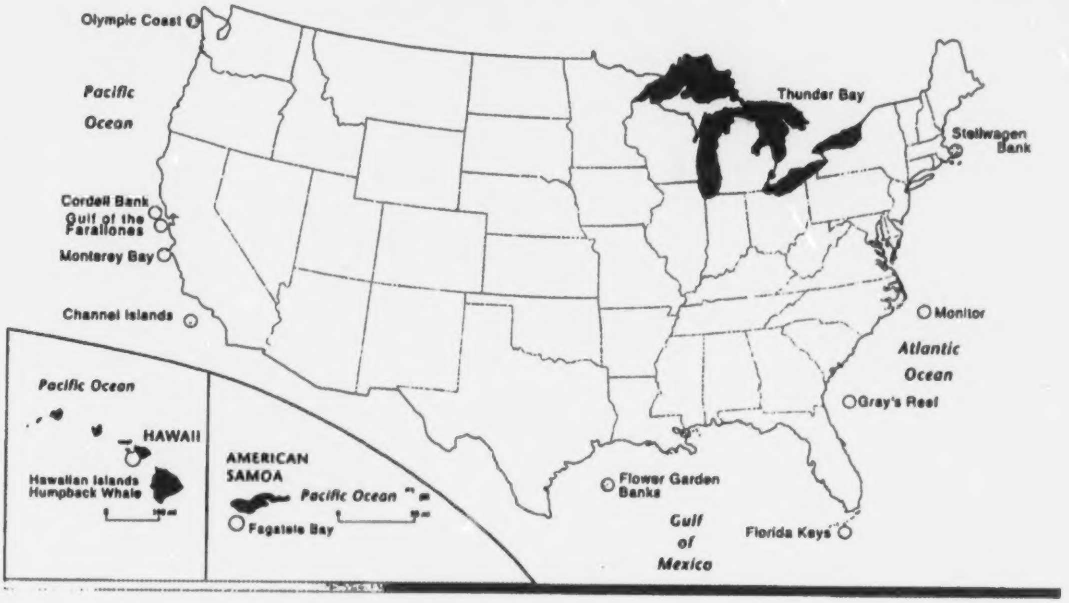
NOAA's National Marine Sanctuaries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Thunder Bay
Stellwagen Bank
Cordell Bank
Gulf of the Farallones
Monterey Bay
Channel Islands
Monitor
Atlantic Ocean
Gray's Reef
Pacific Ocean
HAWAII
Hawaiian Islands Humpback Whale
AMERICAN SAMOA
Pacific Ocean
Fagatele Bay
Flower Garden Banks
Gulf of Mexico
Florida Keys

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Sustainable Seas Expeditions in Your Classroom

Humpback mother and calf © Stan Butler

As an educator, you and your students are invited to join us—and perhaps even guide us—in our underwater missions. You can follow the *Sustainable Seas Expeditions* and mission logs on the Internet; discuss ocean science, policy, and management in your classroom; engage students in designing their own submersibles; or see the DeepWorker submersible up close at one of the open houses.

Your most important role, however, is to foster within students the questioning attitude that is at the heart of the explorer. A new generation of ocean citizens occupies our classrooms now. Among them are the technicians, scientists, civic leaders, and voters of tomorrow—those who inherit our oceans' problems and will be challenged to find their solutions. Among them also are the next ocean explorers, those whose curiosity, personal motivation, and commitment will carry them beyond what we know now.

For your students, the *Sustainable Seas Expeditions* are an exciting application of science and geography in action. For teachers, the *Expeditions* provide a way of using the National Science Education Standards and the National Geography Standards to truly involve your students in their own learning. The teaching ideas suggested here, as well as in other *Expeditions*-related education materials developed by the National Science Teachers Association, the National Geographic Society, and NOAA's National Marine Sanctuaries, build on the content and methods of these two standards documents.

These *Expeditions* are an opportunity to engage students in the excitement of real-time exploration—the heart of the study of geography and science. These inquiry-based disciplines work together to increase our understanding of Earth and its systems. Integral to most activities are the geography standard skills—asking geographic questions; acquiring geographic information; then organizing, analyzing, and answering these geographic questions.

Integral also are the methods of inquiry teaching, of assessment, and of systems thinking that form the core of the science education standards. As students explore the oceans—sampling the diversity of life and undersea topography at each of our 13 marine sanctuaries—we hope that these methods allow them to link the world beneath the surface of the sea to their view of the blue planet.

Adapt the activities as necessary to best meet the needs of your students and the specific location in which you live. Some of the activities, such as conducting a vertical transect and studying features of a particular sanctuary, can be adapted to your area by replacing the data provided with that from your local sanctuary.

INVESTIGATION 1

What Are Marine Sanctuaries?

In this Investigation, students develop their understanding of what a marine sanctuary is and consider the criteria used in defining these special places.

BACKGROUND INFORMATION

NOAA's National Marine Sanctuaries
National Marine Sanctuary Sites

ACTIVITY

Special Places in the Sea

LEARNING OBJECTIVES

Students will:

- Define what a marine sanctuary is in their own words;
- Compare and contrast the national marine sanctuaries for similarities and differences in ecosystems, human use, water temperature, currents, and undersea topography;
- Articulate why we need national marine sanctuaries.

STANDARDS

Geography Standard 1
How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

Geography Standard 8
Characteristics and spatial distribution of ecosystems on Earth's surface

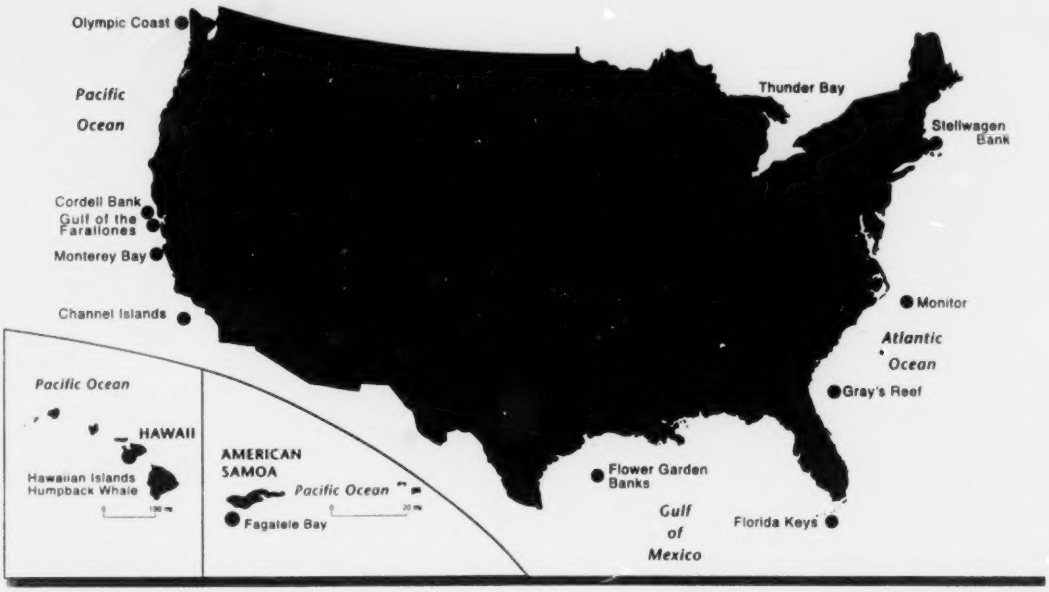
Science Education Standards
How to identify worthwhile and researchable questions, plan an investigation, execute a research plan, and draft a research report

Developing self-directed learners

ACTIVITY

Special Places in the Sea

NOAA's National Marine Sanctuaries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Stellwagen Bank
Monitor
Atlantic Ocean
Gray's Reef
Flower Garden Banks
Gulf of Mexico
Florida Keys
Pacific Ocean
HAWAII
Hawaiian Islands Humpback Whale
AMERICAN SAMOA
Pacific Ocean
Fagatele Bay

Guiding Question

What characteristics define a marine sanctuary?

Materials

- ☐ **World Map**, one for each student group
- ☐ **Exploring the Sanctuaries**, one for each student group
- ☐ Copy of sanctuary descriptions from **National Marine Sanctuary Sites** (pp. 16–23) for each student group
- ☐ Latitude, longitude, and web site address for each of the 13 national marine sanctuaries (page 30)
- ☐ *Sustainable Seas Expeditions* poster (for a copy call 805/963-3238)
- ☐ Access to the Internet
- ☐ Paper for student journals or lab notebooks

Procedure

Part 1: What is a Marine Sanctuary?

1 On the board or overhead projector, write the words "marine sanctuary." Tell students that 13 national marine sanctuaries have been set aside in the United States since 1972.

2 Using **NOAA's National Marine Sanctuaries Background Information** sheet on page 6 as a guide, describe to your students why marine sanctuaries were established and how they are managed. Start them thinking about what marine sanctuaries are—establishing what they already know and encouraging them to ask and answer their own questions about sanctuaries and the marine environment.

3 Discuss with students the role of national parks, both on land and at sea, as special places that preserve algae, plants, and animals, the habitats in which they live, unique landforms, and recreational opportunities for people. Compare the establishment of the first national park, Yellowstone, in 1872 to the establishment of the first national marine sanctuary, *Monitor,* about one hundred years later.

4 After the discussion, divide your class into groups of three or four students each. Give each group a **World Map** and the name, latitude, and longitude of one or more of the 13 sanctuaries. (A point has been chosen for each site.) Ask students to locate their sanctuaries on the **Map**.

Part 2: What Makes Each Sanctuary Special?

1 Hand out an **Exploring the Sanctuaries** sheet to each group. Using this as a guide, have groups predict what biological, physical, and geographical features they might find at the latitude and longitude of their mapped sanctuaries. Encourage students to identify what they don't know and to record questions in their lab notebooks concerning what they would like to learn more about. These questions may serve as a starting point for Investigation 3, **Planning an Expedition**.

2 Have students collect data about their sanctuaries that address their questions. Give each group the sanctuary description and web site address for their sanctuary. Have them revisit the questions on the **Exploring the Sanctuaries** handout and in their lab notebooks to build on what they already know and form a more complete description of their sanctuaries. How do their predictions compare to their findings?

3 Have groups present what they have learned to the rest of the class. Encourage students to describe the sanctuary they studied and make comparisons with other sanctuaries. Some discussion questions might include:

What did students expect to find in terms of key habitats, species, ocean currents, water temperature, geological features, and human uses?

What was the reasoning behind their expectations?

How did their research change their knowledge of their marine sanctuary?

Why do they think their area was designated as a sanctuary?

Part 3: Defining Sanctuaries

Based upon the students' presentations and discussions, continue the discussion to further explore what characteristics define a sanctuary.

How do the features of one sanctuary compare to another? Which have coral reefs? Why? Which have kelp forests?

(This can be a lengthy discussion where students begin to look at what defines a sanctuary. Point out, if students haven't already, the diversity among sanctuaries with respect to habitat types, water temperature, ocean currents, geology, human use, and so on.)

What is the unifying concept among all the different sanctuaries? What defines a sanctuary?

What kinds of areas should qualify as a sanctuary?

(As part of this discussion, have students reflect on the reasons why their sanctuaries were designated as such. Are all designated for the same reasons? For more information, refer to the resources listed under National Marine Sanctuary Program on page 88.)

What activities should be allowed in a sanctuary? What are the pros and cons of designating certain areas as multi-use or single use? What are the pros and cons of setting aside areas where no activities are allowed at all? What permitted activities do students agree/disagree with? What are the pros and cons of these? What points of view do different stakeholders have regarding this issue?

(Have students role play different sanctuary users such as commercial fishermen, recreational divers, and so on.)

What are the benefits of designating areas as sanctuaries? What are the limitations? When considering the size of a sanctuary, how big is big enough?

Why do we need sanctuaries? Are sanctuaries enough to maintain the health of the sea? Are there other methods that would benefit the sea; for example, the corridors employed by the National Park Service that provide routes for animals on land to move from one area to another?

To expand this discussion and compare management strategies between the Great Barrier Reef Marine Park in Australia and our national marine sanctuaries, refer to the Great Barrier Reef's web site (http://www.gbrmpa.gov.au/). In particular, look at the headings "Managing the Great Barrier Marine Park" and "Corporate Plan 1997–2001."

Part 4: Revisit Their Understanding

1 After completing one or more of the other Investigations in this packet, revisit this exercise to see how students' concepts of a marine sanctuary have changed as a result of their own investigations. If students use a journal or lab notebook to record their work, this activity will provide them with a means of self-assessment.

National Marine Sanctuaries: Latitude and Longitude* / Web Site Addresses

Channel Islands National Marine Sanctuary
34° N 119° W http://www.cinms.nos.noaa.gov

Cordell Bank National Marine Sanctuary
38° N 123° W http://www.sanctuaries.nos.noaa.gov/oms/omscordell/omscordell.html

Fagatele Bay National Marine Sanctuary
14° S 170° W http://www.sanctuaries.nos.noaa.gov/oms/omsfagatele/omsfagatele.html

Florida Keys National Marine Sanctuary
24° N 81° W http://www.fknms.nos.noaa.gov

Flower Garden Banks National Marine Sanctuary
27° N 93° W http://www.flowergarden.nos.noaa.gov/

Gray's Reef National Marine Sanctuary
31° N 80° W http://www.graysreef.nos.noaa.gov

Gulf of the Farallones National Marine Sanctuary
37° N 122° W http://www.gfnms.nos.noaa.gov

Hawaiian Islands Humpback Whale National Marine Sanctuary
21° N 157° W http://www.hihwnms.nos.noaa.gov/

Monitor National Marine Sanctuary
35° N 75° W http://www.nos.noaa.gov/nmsp/monitor *or* http://monitor.nos.noaa.gov/

Monterey Bay National Marine Sanctuary
36° N 122° W http://www.mbnms.nos.noaa.gov

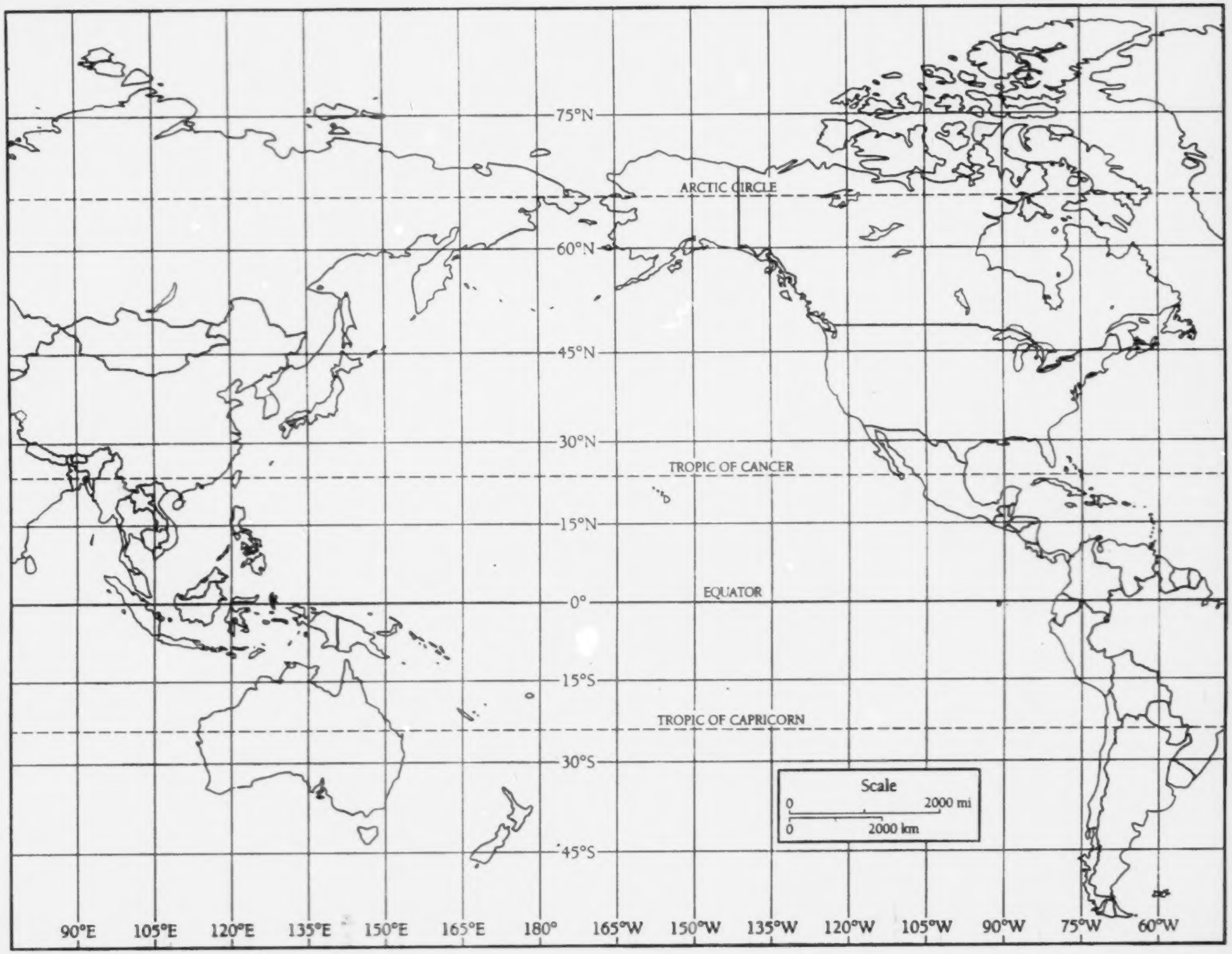
Olympic Coast National Marine Sanctuary
48° N 124° W http://www.ocnms.nos.noaa.gov/

Stellwagen Bank National Marine Sanctuary
42° N 70° W http://vineyard.er.usgs.gov/
http://www.sanctuaries.nos.noaa.gov/oms/omsstellwagen/omsstellwagen.html

Thunder Bay National Marine Sanctuary
45° N 83° W http://www.glerl.noaa.gov/glsr/thunderbay

*Latitude and longitude are measured from a point near the center of the sanctuary.

WORLD MAP


75°N
60°N
45°N
30°N
15°N
0°
15°S
30°S
45°S
ARCTIC CIRCLE
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180°
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150°W
135°W
120°W
105°W
90°W
75°W
60°W

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Geographical Features:

- What major cities are within 150 kilometers (100 miles) of your sanctuary and what are their populations? How accessible is the sanctuary? Can you drive there?
- What are the important geological features of this site? What geological processes helped shape the sanctuary and its surrounding area?

Historical Perspectives:

- What historical features are part of the sanctuary? Are there shipwrecks, native peoples, or archaeological artifacts? How was the area important to early people?

Physical Characteristics:

- How can you characterize the physical conditions of the sanctuary?

Biological Aspects:

- What habitats are found in the sanctuary? What kinds of algae, plants, and animals live in these places? What species are found in more than one habitat? What species might migrate through this sanctuary during certain times of year?

Human Use:

- How do people use the sanctuary? What are the real and potential threats and benefits from those uses?

Goals of the Marine Sanctuary:

- Why do you think this area was designated as a national marine sanctuary? What activities should be allowed? What are some of the current local issues?

INVESTIGATION 2

A Closer Look at One Sanctuary

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© Norm Despres

In this Investigation, students take a closer look at Stellwagen Bank National Marine Sanctuary. After becoming familiar with a topographic map of the area, students select a transect along the seafloor to study some of the geological, biological, and physical features that are present.

ACTIVITY

Conducting a Transect Along the Seafloor: Stellwagen Bank National Marine Sanctuary

LEARNING OBJECTIVES

Students will:

- Use a topographic map as a tool for recognizing geophysical features of the seafloor;
- Create a depth profile from a topographic map;
- Use a transect as a tool for quantifying geological, physical, and biological features along the seafloor;
- Correlate species with habitat type in Stellwagen Bank National Marine Sanctuary.

STANDARDS

Geography Standard 1

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

Science Education Standards

Developing abilities necessary to do scientific inquiry

Developing understanding of populations and ecosystems

INVESTIGATION 2

ACTIVITY

Conducting a Transect Along the Seafloor:

NOAA's Stellwagen Bank National Marine Sanctuary

Guiding Question

If you were to plan a research cruise in Stellwagen Bank National Marine Sanctuary using DeepWorker, what transect would you study? Based upon the habitat types along your transect, what species would you expect to find?

Discussion

As a result of extensive studies of the seafloor in Stellwagen Bank National Marine Sanctuary, much is known about its topography and sediment types. Sediment type is one of many factors that define the kinds of algae and animals living in a particular area. By knowing these sediment types and the habitats preferred by different species, scientists can predict what organisms they might find in an area. Using DeepWorker and other scientific equipment, scientists can compare their predictions with actual findings.

In Stellwagen Bank National Marine Sanctuary, most topographic features and sediment types were formed by glacial processes. Glacial ice containing rock debris moved across the region, scouring its surface and depositing sediment to form basins, banks, knolls, ledges, and other features. Today, storm currents and waves from the northeast continue the process. These currents erode sand and mud from the shallow banks and transport them into the basins. Stellwagen Bank and Jeffreys Ledge are shallow banks (20-40-meter water depth) covered with sand and gravel. Tillies Basin, the area students will focus on, was formed by icebergs scraping along the bottom. It is covered with mud.

Materials

- ☐ **Topographic Map of Tillies Basin Area,** one for each group
- ☐ **3-D map of Tillies Basin Area,** one for each group
- ☐ **Benthic Habitat Types in the Tillies Basin Area,** one for each group
- ☐ **Animal Species in the Tillies Basin Area,** one for each group
- ☐ Metric ruler
- ☐ Graph paper with x- and y-axis
- ☐ Access to the Internet (optional)

Procedure

1 Give each student a copy of the topographic map for the Tillies Basin Area. Discuss with your students the different features on the map (contour lines represent different landforms such as basins, knolls, ledges, and

banks) and how geologists create these maps. What are some ways scientists might use these maps?

2 Explain to students that scientists conduct transect studies as one way to characterize the geological, physical, and biological characteristics of an ecosystem. Tell students that they are going to plan a research cruise in the area of Tillies Basin using DeepWorker. Have them select a horizontal transect on their maps that they would be interested in studying. How do you determine the length and depth of a transect? The transect should be a straight line from one point on the map to another. Using a ruler, have

HOW ARE SEAFLOOR MAPS CREATED?

Most of our knowledge about seafloor topography comes from soundings: sending sound waves into the water and measuring the time it takes for them to bounce off the ocean floor and return. From these soundings, scientists can create a map of the seafloor.

The device used to send sound waves is called an echo sounder, or sonar. Towed behind a ship, it bounces about 120 narrow beams of sound, also called "pings," off the seafloor several times per second. Another instrument collects the sound that echoes back. The ship passes back and forth over a given area, much the way you mow a lawn, sending these many beams of sound as it goes. A computer on board the boat calculates the depth based on the time it takes for the echo of the beam to return to the surface. Sound travels through the ocean at an average speed of 1,460 meters (4,800 feet) per second. (Sound travels about five times faster through water than it does through air.) To calculate the depth, divide the total amount of time it takes for a ping to hit the bottom and bounce back by two. (You divide by two because the total includes the trip down and back.) Then multiply that figure by 1,460. For instance, if it takes two seconds for sound to return to the ship, the water must be 1,460 meters deep.

At the same time, the sonar gathers information about the composition of the ocean floor by measuring the strength of the returning signal.

For example, mud absorbs sound, therefore a muted echo indicates a muddy bottom. A strong echo indicates a rocky bottom. Scientists supplement these sonar images with videos, still photographs, and samples of the ocean floor.

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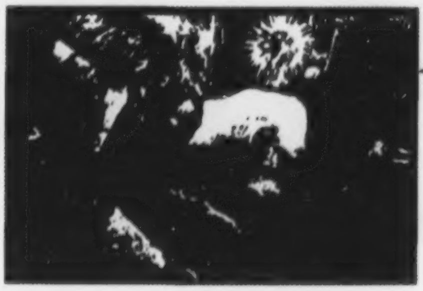


each student draw a straight line on the map to indicate the location of the transect. Are all points along the transect within the depth range of DeepWorker?

3 To help illustrate the underwater topography along a transect, have students make profile charts. On a separate piece of paper, have them create a "T" table: one column for distance from the starting point of their transect (Point A) and one for depth of the seafloor. Then have them collect data at every centimeter along their transect using the scale 1cm = 1 km. For example, measuring one centimeter on the ruler from Point A (which is equal to one kilometer from the starting point of their transect), the contour line indicates depth is 25 meters. At two centimeters (or two kilometers from Point A), the depth is 30 meters (see example below).

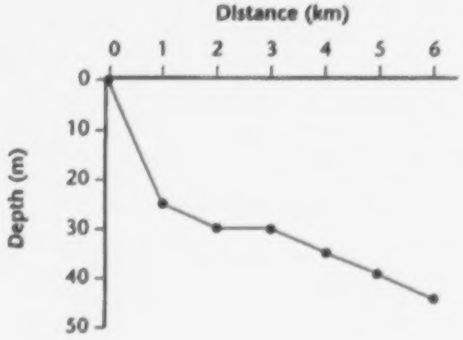
MAPPING THE SEAFLOOR DATA
TRANSECT IN STELLWAGEN BANK NATIONAL
MARINE SANCTUARY

Distance from start (Point A) of transect (m)	*Depth of seafloor (km)*
0 km	0 m
1 km	25 m
2 km	30 m
3 km	30 m
4 km	35 m

4 Once students have collected data along their transects and created data tables, have them create profile charts to show the underwater topography. If computer graphing capabilities are not available, hand out graph paper and have students title and label their graphs: distance (km) along the bottom or X axis, and depth increments (m) along the side or Y axis. Students can refer to their data tables for ranges of values.

5 Have students use their data tables to plot the points on their profile charts, then draw a profile by connecting the points on the chart.

Sample Profile Chart



6 Students can compare their profile charts to the 3-D map in these materials or the seafloor map of Stellwagen Bank on the Internet (http://vineyard.er.usgs.gov/. Click on "New Maps of the Stellwagen Bank National Marine Sanctuary Region on CD-ROM.") Have them match the geophysical features along their transects.

7 Give each student a copy of the **Benthic Habitat Types** handout. Have them determine what kinds of sediments they would find along their transects and indicate these on their maps. Encourage students to ask questions about their findings; for instance, "Did these sediments come from glacial activity?", "Are they transported by oceanic currents?", "Is the sediment distributed in zones according to certain size?" Students may not have answers to these questions, but asking these types of questions is an essential part of doing science and is the first step in scientific inquiry. Their questions may be further addressed in Investigation 3, **Planning an Expedition**.

8 Give each student a copy of the **Animal Species** handout. Based on the sediments found along their transects, what species would they expect to find? What is their reasoning to support these expectations?

9 Discuss with students the relationships among the organisms, their physical surroundings, and their geographic location. What physical conditions does each organism favor? Do the organism's predators and prey favor the same conditions? What kinds of patterns can be seen among organisms, physical conditions, and their geographic location?

10 If you have access to the Internet, have students refer to the *Sustainable Seas Expeditions* web site (www.sustainableseas.noaa.gov) to follow the research being conducted in Stellwagen Bank National Marine Sanctuary. What species are the *Sustainable Seas Expeditions* researchers finding? How do these findings compare with the predictions made by students?

11 Have students write a detailed description of their findings. If they were able to follow the *Sustainable Seas Expeditions* research project on the web, have them draw conclusions about their predictions and the actual findings.

Extension Activity

Have students repeat this activity with the information sheets and maps of the Monterey Bay National Marine Sanctuary (see handouts immediately following the Tillies Basin handouts). Alternatively, divide the class in half. Have one half do the Stellwagen transect and the other half do the Monterey Bay transect. What are the similarities and differences in habitat type and animal species of the two sanctuaries? What are some reasons for these similarities and differences? For site characterization of Monterey National Marine Sanctuary, go to: http://bonita.mbnms.nos.noaa.gov/sitechar/geol2.html#2b

One of the fishes inhabiting NOAA's Stellwagen Bank National Marine Sanctuary is the center of study for an *Expeditions* investigation. Redfish *(Sebastes fasciatus)* congregate in a particular area near Tillies Basin. A related fish, the rockfish *(Sebastes caurinus)* inhabits a similar habitat in NOAA's Monterey Bay National Marine Sanctuary. By comparing the day and night habits of these two fish, scientists hope to find relationships between them which might prove useful when making decisions on how to best protect their populations.

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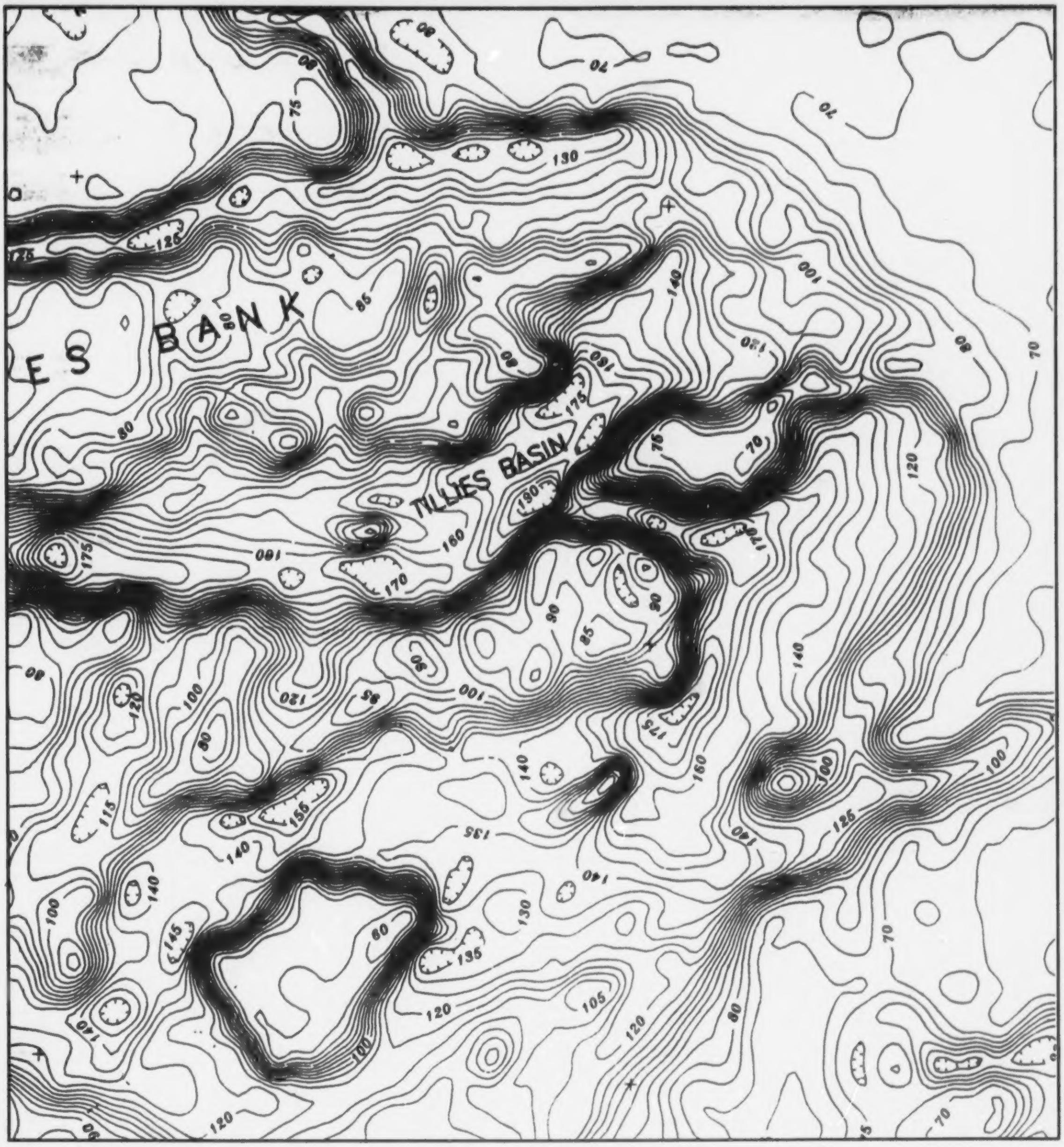
TOPOGRAPHIC MAP OF TILLIES BASIN AREA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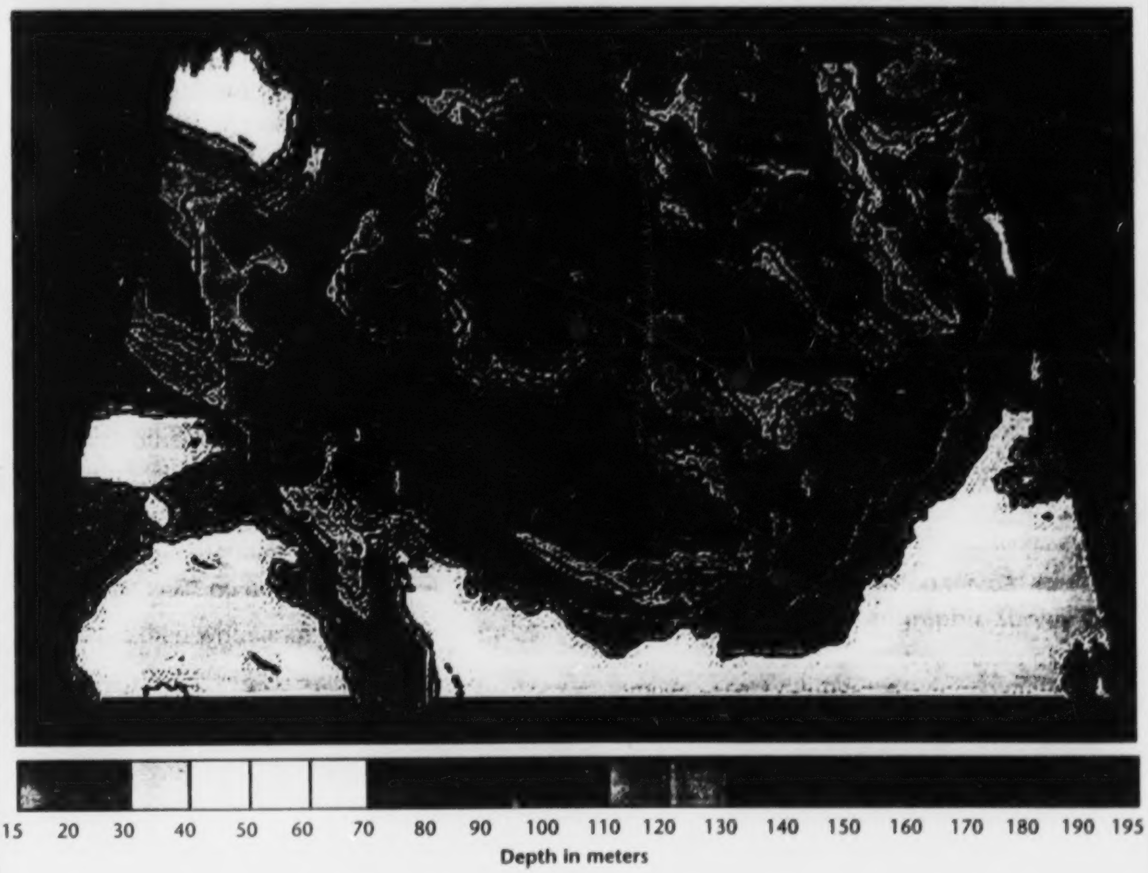
Sustainable Seas Expeditions

3-D MAP OF TILLIES BASIN AREA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Depth in meters

View Direction	From the south
View Distance	25 km from image center
Elevation of View Point	35 degrees above map surface
Vertical Exaggeration	10X
Contour Interval	10 m
Quadrangle Dimensions	East–West: 15.7 km (8.42 nm) North–South: 13.4 km (7.15 nm)
Southwest Corner	42° 26.50' N, 70° 24.67' W
Northeast Corner	42° 33.67' N, 70° 13.33' W

BENTHIC HABITAT TYPES IN THE TILLIES BASIN AREA

Boulder Fields

- Areas with accumulations of small to large rocks of varying height (usually considered to be greater than 256 mm (10 inches) in diameter.
- Found along Jeffreys Ledge in the northern part of the sanctuary; in parts of the Tillies Bank/Basin Area and areas to the east; and on the western rim and southwest corner of Stellwagen Bank. Coordinates for four boulder fields are: 42° 35.25′ N/70° 33.00′ W; 42° 35.97′ N/70° 17.59′ W; 42° 35.65′ N/70° 13.30′ W; and 42° 29.47′ N/70° 13.97′ W.

Gravel/Cobble Fields

- Areas with accumulations of gravel and/or cobble (usually considered to be about 2 mm to about 76 mm in diameter).
- Found on Jeffreys Ledge; on the eastern part of Stellwagen Bank; and on Tillies Bank.

Coarse Sand

- Areas with expanses of sand characterized by grain diameters of 0.5 mm to 1 mm in diameter.
- Found along the top and southwest corner of Stellwagen Bank and on the southern rim of Jeffreys Ledge.

Fine Sand

- Areas with grains of about 0.1 mm to 0.25 mm in diameter.
- Found along the western edge and southern portion of Stellwagen Bank; off the southwestern flank of Stellwagen Bank; and in the channel between Stellwagen Bank and Cape Cod.

Mud/Silt

- Areas with extremely fine particles, usually between 0.004 mm to 0.07 mm in diameter.
- Found in the low-lying basins and deep holes throughout the sanctuary including Stellwagen Basin and Tillies Basin.

Sustainable Seas Expeditions

ANIMAL SPECIES IN THE TILLIES BASIN AREA

Common Name: American lobster
Scientific Name: *Homarus americanus*
Habitat Preference: boulders, gravel, sand
Prey: shrimps, amphipods, bivalves, echinoderms, small fish
Predators: large demersal fish, humans (eaten by lots of marine creatures when young)

Common Name: Sand shrimp
Scientific Name: *Crangon septemspinosa*
Habitat Preference: sand, mud
Prey: algae, phytoplankton, detritus, marine worms, copepods, other small crustaceans
Predators: demersal fish (cod, cusk, flounders, hakes, pollock, sculpin, sea raven, skates, spiny dogfish), herring, striped bass, sea turtles

Common Name: Northern (pink) shrimp
Scientific Name: *Pandalus borealis*
Habitat Preference:: mud
Prey: algae, phytoplankton, detritus, marine worms, copepods and other small crustaceans
Predators: demersal fish, herring, striped bass, sea turtles, humans

Common Name: Surf clam
Scientific Name: *Spisula solidissima*
Habitat Preference: sand
Prey: phytoplankton, small detritus
Predators: marine worms, gastropods, sea stars, large crustaceans (crabs and lobsters), some demersal fish (cod, cusk, wolffish), humans

Common Name: Sea scallop
Scientific Name: *Placopecten magellanica*
Habitat Preference: sand
Prey: phytoplankton, small detritus
Predators: marine worms, gastropods, sea stars, large crustaceans (crabs and lobsters), some demersal fish, humans

Common Name: Sea stars
Scientific Name: *Solaster endeca* (smooth sunstar), *Crossaster papposus* (spiny sunstar), *Asterias vulgaris* (northern sea star), *Leptasterias sp.* (sea star)
Habitat Preference: gravel, sand
Prey: bivalves, small crustaceans, worms, other echinoderms, detritus, carcasses, tunicates, hydroids, sea anemones, sponges
Predators: sea stars, wolffish, pout, cod, worms

Common Name: Hydroids
Scientific Name: *Corymorpha sp.* (solitary), *Tubularia crocea* (pink-hearted)
Habitat Preference: gravel, sand
Prey: zooplankton, phytoplankton, small detritus
Predators: nudibranchs, echinoderms, demersal fish (cod, haddock, flounders, sculpins)

Common Name: Nudibranchs
Scientific Name: *Coryphella spp.* (red-gilled), *Aeolida papillosa* (maned)
Habitat Preference: gravel, sand
Prey: (selective by species) hydroids, sea anemones, cerianthids, corals, bryozoans, sponges
Predators: sea stars, crabs, lobster, some demersal fish

Common Name: Northern cerianthid
Scientific Name: *Cerianthus borealis*
Habitat Preference: mud
Prey: small zooplankton, detritus, small animals that get caught on tentacles
Predators: nudibranchs, sea stars, some bottom-feeding fish (cod, flounder, haddock)

Common Name: Sea anemones
Scientific Name: *Urticina felina* (northern red), *Metridium senile* (frilled)
Habitat Preference: mud
Prey: zooplankton, detritus, small animals that get caught on tentacles
Predators: nudibranchs, sea stars, bottom-feeding fish (cod, flounder, haddock)

Common Name: Sponges
Scientific Name: *Isodictia palmata* (palmate), *Polymastia spp.* (yellow globular)
Habitat Preference: boulders, gravel
Prey: phytoplankton, protozoa, small detritus
Predators: nudibranchs, sea turtles, sea urchins, sea stars

Common Name: Bryozoans
Scientific Name: *Bugula turrita*
Habitat Preference: boulders, gravel
Prey: phytoplankton, protozoa, small zooplankton, small detritus
Predators: nudibranchs, sea spiders, by-catch of haddock, pout, wolffish

Common Name: Mysid shrimp
Scientific Name: *Neomysis americana*
Habitat Preference: mud, sand
Prey: phytoplankton, benthic algae, detritus
Predators: benthic fish, squid

Common Name: Amphipods
Scientific Name: *Gammarus annulatus*
Habitat Preference: mud, sand
Prey: phytoplankton, benthic algae, detritus
Predators: benthic fish, squid, larger crustaceans

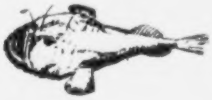
Common Name: Sand dollars
Scientific Name: *Echinarachnius parma*
Habitat Preference: sand
Prey: benthic algae, bryozoans, encrusting sponges, small detritus
Predators: sea stars, wolffish, ocean pout, cod, cusk, sculpin

Sustainable Seas Expeditions

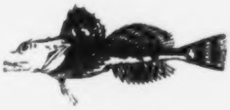
ANIMAL SPECIES IN THE TILLIES BASIN AREA

Common Name: Green sea urchin
Scientific Name: *Strongiyocentrotus droebachiensis*
Habitat Preference: sand
Prey: benthic algae, small detritus
Predators: sea stars, wolffish, ocean pout, cod, cusk, sculpin, humans

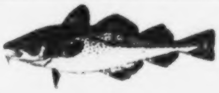
Common Name: Squid
Scientific Name: *Illex illecebrosus* (shortfin squid), *Loligo pealei* (longfin squid)
Habitat Preference: open water, sand and gravel (depressions at night)
Prey: small fish (herring, mackerel, sand lance), krill, amphipods, mysids
Predators: toothed whales, bluefin tuna, bluefish, cod, sharks, dogfish, humans



Common Name: Goosefish
Scientific Name: *Lophius americanus*
Habitat Preference: sand, mud
Prey: most fish, squid, crustaceans, worms, occasional bird
Predators: goosefish, large sharks, young preyed upon by many pelagic species, humans

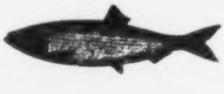


Common Name: Sculpins
Scientific Name: *Myoxocephalus octodecemspinosus* (longhorn sculpin), *Myoxocephalus scorpius* (shorthorn sculpin), *Hermitripterus americanus* (sea raven)
Habitat Preference: gravel
Prey: demersal fish, squid, crustaceans, mollusks, echinoderms, worms, also scavenges on carcasses
Predators: goosefish, other sculpin



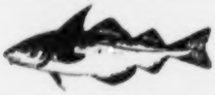
Common Name: Atlantic cod
Scientific Name: *Gadus morhua*
Habitat Preference: boulders, gravel, sand, mud
Prey: demersal fish, crustaceans, mollusks, echinoderms, anemones and hydroids, squid, worms, bryozoans
Predators: goosefish, sea raven, young eaten by many bottom fish, humans

Common Name: American sand lance
Scientific Name: *Ammodytes americanus*
Habitat Preference: sand
Prey: zooplankton (especially copepods), worms, larval fish and invertebrates
Predators: most pelagic and demersal fish, squid, marine mammals, sea birds

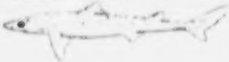


Common Name: Herring
Scientific Name: *Clupea harengus*
Habitat Preference: open water, gravel for egg laying
Prey: small fish, zooplankton (especially copepods), amphipods, mysids, shrimps, worms
Predators: many pelagic and demersal fish, squid, marine mammals, sea birds, humans

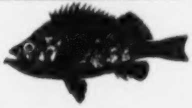
Common Name: Wolffish
Scientific Name: *Anarhichas lupus*
Habitat Preference: boulders
Prey:: echinoderms, crustaceans, mollusks
Predators: goosefish, sea raven, young preyed upon by other bottom fish, humans



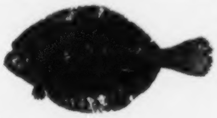
Common Name: Haddock
Scientific Name: *Melanogrammus aeglefinus*
Habitat Preference: boulders
Prey: mollusks, echinoderms, anemones and hydroids, worms, squid, sand lance, crustaceans
Predators: bluefish, cod, goosefish, sea raven, sharks, humans



Common Name: Spiny dogfish
Scientific Name: *Squalus acanthias*
Habitat Preference: gravel, sand
Prey: small fish (pelagic and demersal), squid, crustaceans, bivalves, worms, jellyfish, salps
Predators: goosefish, other dogfish, large sharks, humans



Common Name: Acadian redfish
Scientific Name: *Sebastes fasciatus*
Habitat Preference: boulders
Prey: mollusks, crustaceans, squid
Predators: cod, goosefish, spiny dogfish, sea raven, hakes, humans

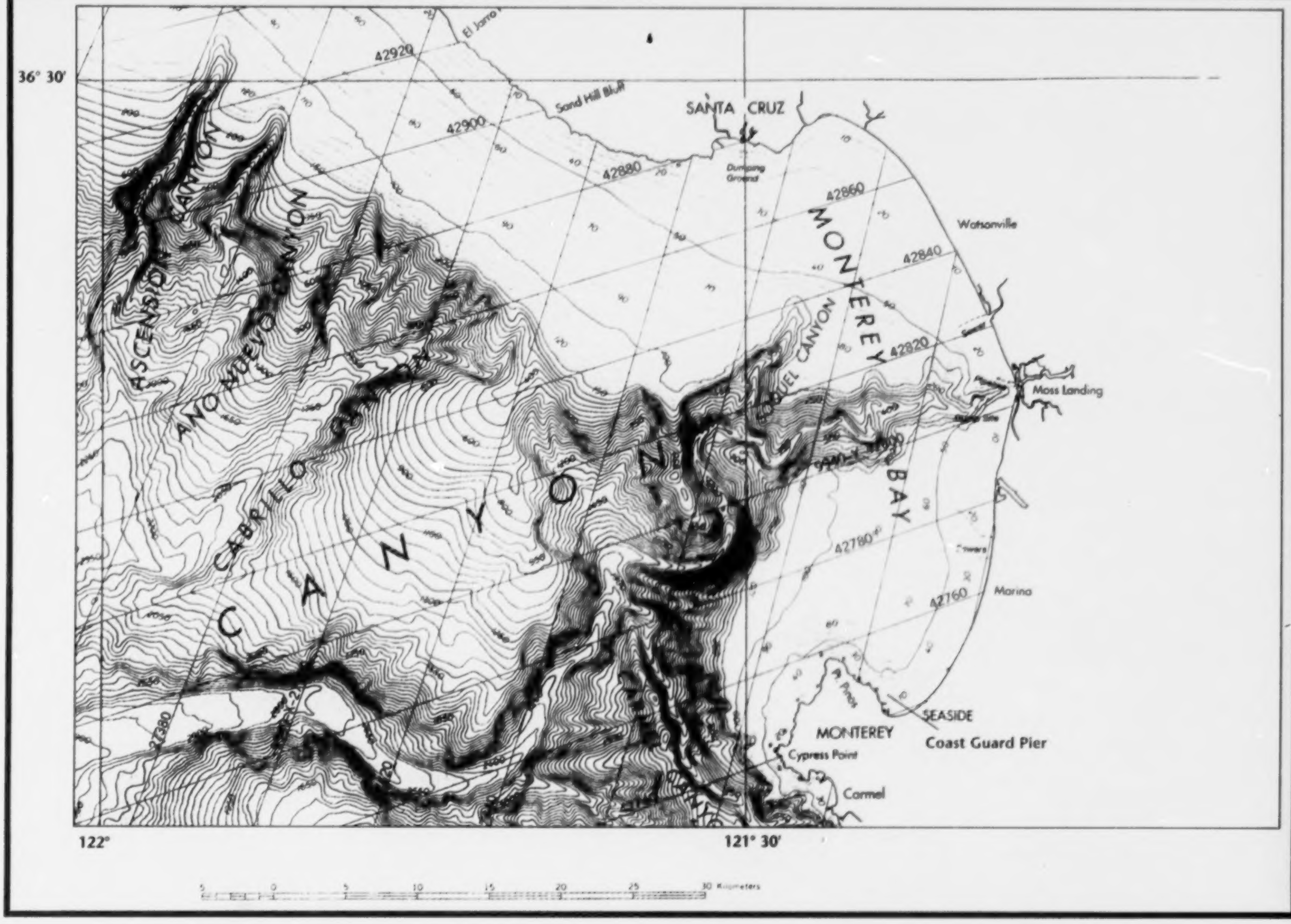


Common Name: American plaice
Scientific Name: *Hippoglossoides platessoides*
Habitat Preference: mud, sand
Prey: small mollusks and crustaceans, small fish, anemones and hydroids, worms
Predators: cod, goosefish, sea raven, skates, dogfish, humans

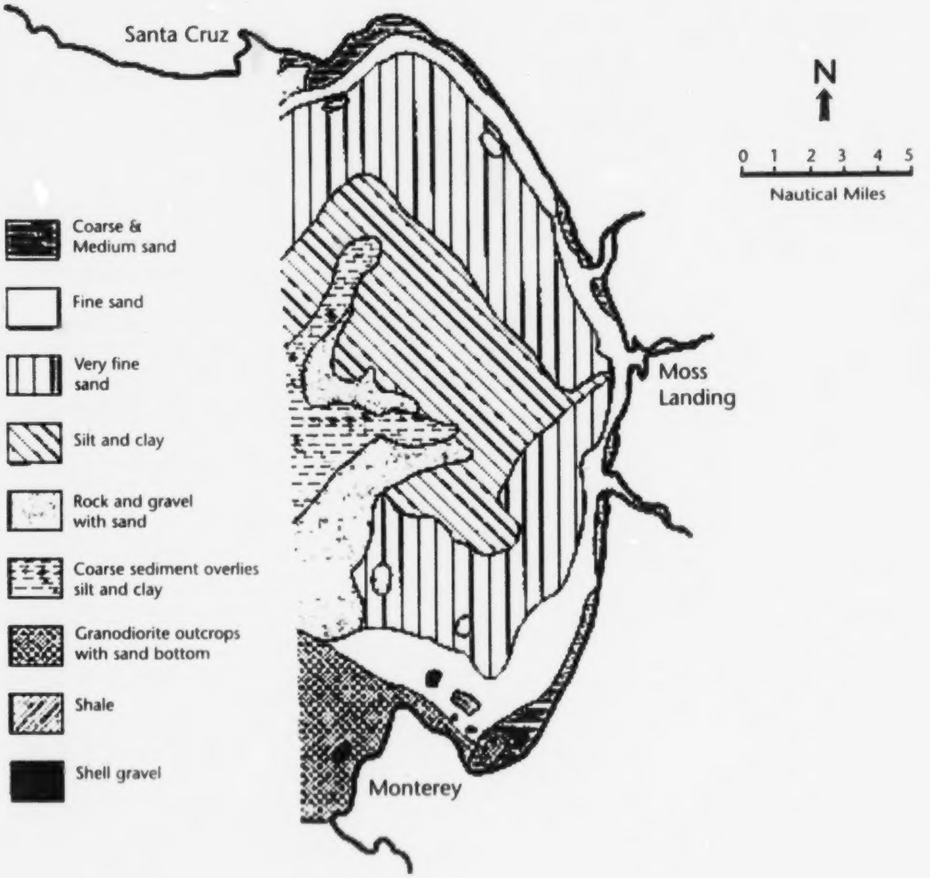
Common Name: Skates
Scientific Name: *Raja erinacea* (little), *Raja ocellata* (winter)
Habitat Preference: sand
Prey: small fish, squid, crustaceans, mollusks, anemones and hydroids, echinoderms, worms
Predators: sharks, goosefish, humans

Sustainable Seas Expeditions

MONTEREY BAY SANCTUARY BATHYMETRIC CHART


36° 30'
122°
121° 30'
El Jarro Pt
Sand Hill Bluff
SANTA CRUZ
Dumping Ground
Watsonville
Moss Landing
Marina
SEASIDE
MONTEREY
Coast Guard Pier
Cypress Point
Carmel
Pt. Pinos
ASCENSION CANYON
AÑO NUEVO CANYON
CABRILLO CANYON
MONTEREY CANYON
SOQUEL CANYON
MONTEREY BAY
42920
42900
42880
42860
42840
42820
42780
42760
27380
5 0 5 10 15 20 25 30 Kilometers

BENTHIC HABITAT TYPES IN THE MONTEREY CANYON AREA


Santa Cruz
Moss Landing
Monterey
N
0 1 2 3 4 5
Nautical Miles
Coarse & Medium sand
Fine sand
Very fine sand
Silt and clay
Rock and gravel with sand
Coarse sediment overlies silt and clay
Granodiorite outcrops with sand bottom
Shale
Shell gravel

*Drawing from "Natural History of the Monterey Bay National Marine Sanctuary"
This book is available from the Monterey Bay Sanctuary Foundation at their website: www.mbnmsf.org

ANIMAL SPECIES IN THE MONTEREY BAY NATIONAL MARINE SANCTUARY

Common Name: Olive snail
Scientific Name: *Olivella biplicata*
Habitat Preference: fine sand
Prey: algae & dead animals
Predators: sea stars

Common Name: Red octopus
Scientific Name: *Octopus*
Habitat Preference: rocky outcrops
Prey: small crustaceans, mollusks and fishes
Predators: demersal fish, herring, striped bass, sea turtles, humans

Common Name: Pismo clam
Scientific Name: *Tivela stultorum*
Habitat Preference: coarse and medium sand
Prey: phytoplankton, small detritus
Predators: sea otters, crabs, moon snails, sharks, rays, shorebirds, & humans

Common Name: Cold seep clams
Scientific Name: *Calyptogena spp.*
Habitat Preference: Cold seep areas in the deep canyon floor. Coarse sediment with silt and clay
Prey: chemosynthetic bacteria live in the clams gill tissues and provide their sole source of nutrition
Predators: unknown

Common Name: Sea stars
Scientific Name: *Patira miniata* (bat star), *Pisaster giganteus* (Giant seastar), *Astropecten armatus* (sand star),
Habitat Preference: coarse and medium sand, rocks
Prey: bivalves, small crustaceans, worms, other echinoderms, detritus, carcasses, tunicates, hydroids, sea anemones, sponges
Predators: larger sea stars, gulls & humans

Common Name: Hydroid
Scientific Name: *Aglaophenia spp.* (ostrich-plumed)
Habitat Preference: gravel, sand
Prey: zooplankton, phytoplankton, small detritus
Predators: nudibranchs, echinoderms, benthic fish (flounders, sculpins)

Common Name: Nudibranchs & Opistobranchs
Scientific Name: *Anisodoris nobilis* (Sea lemon), *Pleurobrachia california* (Deep sea hare)
Habitat Preference: rocky outcrops
Prey: (selective by species) hydroids, sea anemones, cerianthids, corals, bryozoans, sponges
Predators: sea stars, crabs, lobster, some benthic fish

Common Name: Tube-dwelling anemone
Scientific Name: *Pachycerianthus fimbriatus*
Habitat Preference: fine sand or mud
Prey: small zooplankton, detritus, small animals that get caught on tentacles
Predators: nudibranchs, sea stars, some bottom-feeding fish (cod, flounder, haddock)

Common Name: Sea anemones
Scientific Name: *Corynactis californica* (strawberry anemone), *Metridium senile* (plume anemone)
Habitat Preference: rocks
Prey: zooplankton, detritus, small animals that get caught on tentacles
Predators: nudibranchs, sea stars, bottom-feeding fish

Common Name: Crabs
Scientific Name: *Cancer magister* (dungeness crab), *Pagurus samuelis.* (hermit crab)
Habitat Preference: boulders, gravel
Prey: phytoplankton, protozoa, small detritus
Predators: nudibranchs, sea turtles, sea urchins, sea stars

Common Name: Bryozoans
Scientific Name: *Filicrisia franciscana*
Habitat Preference: rocks & shale
Prey: phytoplankton, protozoa, small zooplankton, small detritus
Predators: nudibranchs, crabs

Common Name: Tunicate (carnivorous)
Scientific Name: *Megalodicopia hians*
Habitat Preference: deep area of canyon walls
Prey: copepods, krill, & other zooplankton
Predators: unknown

Common Name: Giant tube worms (grow up to 1 meter long)
Scientific Name: *Riftia spp.*
Habitat Preference: hot hydrothermal vents found on the deep seafloor of the canyon; shale and mud
Prey: chemosynthetic bacteria live in the worms tissues and provide nutrition
Predators: unknown

Common Name: Sand dollar
Scientific Name: *Dendraster excentricus*
Habitat Preference: fine sand & muddy bottoms
Prey: benthic algae, bryozoans, encrusting sponges, small detritus, small copepods
Predators: sheephead, starry flounder, pink sea star, gulls

ANIMAL SPECIES IN THE MONTEREY BAY NATIONAL MARINE SANCTUARY

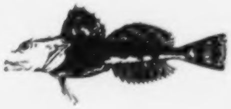
Common Name: Purple sea urchin
Scientific Name: *Strongylocentrotus purpuratus*
Habitat Preference: rocky outcrops
Prey: benthic algae, small detritus, plankton
Predators: sea stars, some fishes (California sheephead), sea otters, & humans

Common Name: Common squid
Scientific Name: *Loligo opalescens*
Habitat Preference: open water, muddy sand (for spawning)
Prey: shrimplike crustaceans, small fishes, benthic worms, & their own young
Predators: Many fishes, birds, marine mammals & humans

Common Name: Blue rockfish
Scientific Name: *Sebastes mystinus*
Habitat Preference: kelp plants & rocky areas
Prey: mollusks, squid, crustaceans, worms,
Predators: bigger fishes, young preyed upon by many pelagic species, humans

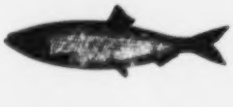
Common Name: Cabezon
Scientific Name: *Scorpaenichthys marmoratus*
Habitat Preference: rock & gravel
Prey: demersal fish, abalone, crustaceans, mollusks, echinoderms, worms, also scavenges on carcasses
Predators: humans

Common Name: Tidepool sculpin
Scientific Name: *Oligocottus maculosus*
Habitat Preference: shallow rocky areas
Prey: demersal fish, crustaceans, mollusks, echinoderms, worms, also scavenges on carcasses
Predators: young eaten by many bottom fish



Common Name: California halibut
Scientific Name: *Paralichthys californicus*
Habitat Preference: fine or coarse sand
Prey: small fishes, crustaceans
Predators: pelagic and benthic fish, squid, marine mammals, sea birds

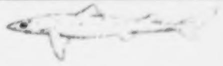
Common Name: Pacific herring
Scientific Name: *Clupea harengus*
Habitat Preference: open water, gravel for egg laying
Prey: small fish, zooplankton (especially copepods), amphipods, mysids, shrimps, worms
Predators: many pelagic and benthic fish, squid, marine mammals, sea birds, humans



Common Name: Lanternfish
Scientific Name: *Myctophidae*
Habitat Preference: open water in the deep sea
Prey: copepods & euphausiids
Predators: deep sea fish such as barracudinas & squid

Common Name: Speckled sanddab
Scientific Name: *Citharichthys stigmaus*
Habitat Preference: fine sand
Prey: Mostly crustaceans, plus worms and fishes.
Predators: Diving birds like cormorants, marine mammals, crabs, and other fishes

Common Name: Spiny dogfish
Scientific Name: *Squalus acanthias*
Habitat Preference: gravel, sand
Prey: small fish (pelagic and benthic)), squid, crustaceans, bivalves, worms, jellyfish, salps
Predators: other dogfish, large sharks, humans



Common Name: Shiner surfperch
Scientific Name: *Cymatogaster aggregata*
Habitat Preference: kelp forest, rocks
Prey: Eats small crustaceans, algae, and sometimes worms and molluscs.
Predators Birds, fishes, and marine mammals. Often caught by sportfishermen, usually from piers.

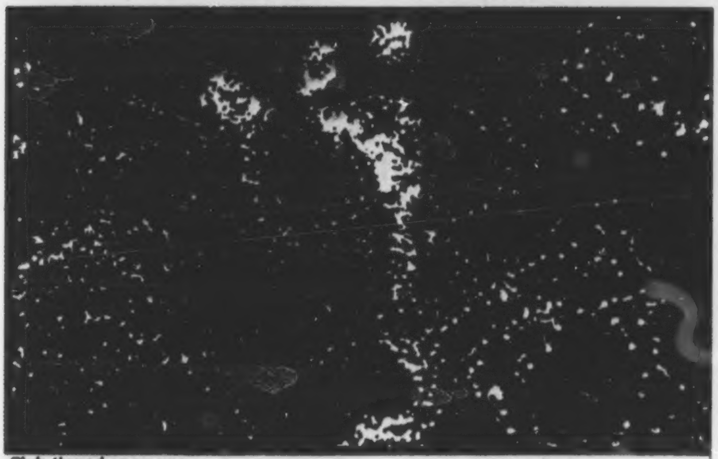
Common Name: Northern anchovy
Scientific Name: *Engraulis morda*
Habitat Preference: open water
Prey: Filters phytoplankton and zooplankton through its fine gill rakers.
Predators: Virtually all predatory birds, fishes (including white croakers), and mammals eat anchovies. Some pizza-lovers too. Often used as bait.

Common Name: Bat ray
Scientific Name: *Myliobatis californica*
Habitat Preference: sand & mud
Prey: Clams, oysters, snails, crabs, and worms.
Predators: Some humans, and possibly hammerhead sharks

Common Name: Leopard shark
Scientific Name: *Triakis semifasciata*
Habitat Preference: sand & mud
Prey: Bottom-dwelling fishes and invertebrates.
Predators: Humans are the main predators of adult sharks. Young ones may be vulnerable to marine mammals, adult sharks, and large fishes.

INVESTIGATION 3

Planning an Expedition



Club-tipped anemone

Laura Francis

In this investigation, students design their own scientific expedition to the sea using the goals of Sustainable Seas Expeditions *as a guide. They begin by conducting a simulated vertical transect as an example of one method scientists use in oceanic research.*

BACKGROUND INFORMATION

Exploring—For Answers
Sustainable Seas Expeditions Research
Meet DeepWorker
NOAA's National Marine Sanctuaries
National Marine Sanctuary Sites

ACTIVITIES

Sample Mission: Vertical Transect
Planning Your SSE Mission

LEARNING OBJECTIVES

Students will:

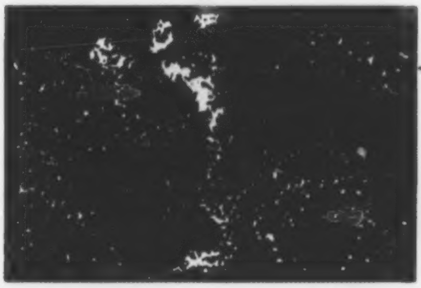
- Conduct a simulated vertical transect in the sea as one method of doing research;
- Plan and design a scientific investigation that meets the goals of *Sustainable Seas Expeditions* and recognizes the capabilities of DeepWorker.

STANDARDS

Geography Standard 3
How to analyze the spatial organization of people, places, and environments on the Earth's surface

Geography Standard 18
How to apply geography to interpret the present and plan for the future

Science Education Standards
Recognizing and developing abilities necessary to design and conduct scientific investigations



ACTIVITY

Sample Mission: Vertical Transect

Guiding Question

What is a vertical transect? How do scientists use this method to determine the layering system of physical and biological parts in the ocean?

Discussion

Scientists often face the problem of trying to accurately interpret a natural system based upon the limited data they are able to collect in the field. Caught between their limited budgets and time constraints, scientists seek methods of sampling which provide the most reliable picture with the least number of samples. Practical restrictions and logistics prevent collecting and mapping every physical feature and organism encountered. Taking such a thorough approach is not necessary; and it could have significant ecological impacts on the community being studied. Using the information provided by a limited number of samples, scientists attempt to construct reliable models of algal, plant, and animal communities.

During *Sustainble Seas Expeditions,* scientists may try to determine how the ocean is stratified by collecting information about the chemical and physical properties of sea water as a function of depth in a vertical transect. The use of a small research submersible like DeepWorker allows a scientist to collect samples in the water column while simultaneously conducting a video survey of animals encountered at a site.

In this activity, students conduct a simulated vertical transect, providing them with an example of one sampling method that they may consider for their scientific investigations. The data represents a vertical transect in Monterey Bay, but may be replaced with data from other locations.

Materials

- ☐ **Dive Mission Cards,** one set for the class
- ☐ **Water Sample Cards,** one set for the class
- ☐ **Photographic Survey Cards,** one set for the class
- ☐ **Wild Cards,** one set for the class
- ☐ **Dive Plan and Pre-Dive Logistics Sheet,** one for each group
- ☐ **Monterey Bay National Marine Sanctuary Chart,** one for each group
- ☐ Internet access (optional)
- ☐ Computer graphing program (optional) or copies of **Graph Grid** and colored pencils

Procedure

1 Student "pilots" will conduct a simulated dive aboard the DeepWorker 2000 into Monterey Submarine Canyon to a maximum depth of 600 meters (2,000 feet).

2 Organize the cards as follows: **Dive Mission Cards** and **Wild Cards** in separate containers to be selected by students randomly; **Water Sample Cards** and **Photographic Survey Cards** arranged into separate piles according to depth (beginning at the surface and making separate piles for each depth down to 600 meters). Each pilot begins by drawing a **Dive Mission Card** that describes the research objective. (**Dive Mission Cards** describe vertical transects of various depths.) Pilots then decide how to complete the vertical transect. For example, a pilot could take single samples at either even or random spacing between collection sites; or they could collect multiple samples at one depth. The pilot must then write and file a **Dive Plan** that specifies the sampling technique to be used.

3 The pilot locates a dive site in the canyon on the **Monterey Bay National Marine Sanctuary Chart**. Under **Pre-Dive Logistics**, each pilot records the depth of the water column at the site as well as the distance from Monterey Coast Guard Pier to the dive site. A general description of the site's bathymetry should also be included. Have pilots select a **Wild Card** prior to their dive and follow the instructions written on the card.

4 The pilot collects a **Water Sample** and makes a **Photographic Survey** at intervals during the descent according to the **Dive Plan**. Samples are available at 50-meter intervals starting at the surface and ending on the floor of the canyon at a depth of 600 meters.

5 A pilot may only collect a total of 10 samples each due to the limited dive time available. As many as four samples may be collected from one particular depth.

6 Pilots must "return to the surface" and process the data collected by constructing a graph that illustrates the stratification of the sea. Use the **Graph Grid** if a computer graphing program is not available. Colored pencils may be used to distinguish between pressure, temperature, salinity, and dissolved oxygen data.

7 The pilot refers to posters, slide sets, and on-line sources for illustrations of organisms identified on the **Photographic Survey Cards**. Have pilots draw and label pictures of organisms encountered in their lab notebooks.

DIVE PLAN AND PRE-DIVE LOGISTICS SHEET

Dive Plan: The **Dive Mission Card** called for me to make a vertical transect from the surface to 400m and allows me to take 10 water samples. I plan to take one sample every 50 meters while descending from the surface to 400 meters and to take the tenth (and final) sample upon returning to the surface because there is likely to be greater variability in water chemistry at the water/air interface. Pressure, temperature, salinity, and dissolved oxygen data will be collected at each site.

Pre-Dive Logistics: My dive site is located in Monterey submarine canyon 10.7 miles (17.8 kilometers) northwest (335°) of the Monterey Coast Guard pier. This area is west of the head of the canyon in 376 fathoms (2,256 feet/688 meters) of water. The bathymetry of the canyon in this location indicates a steep dropoff.

Conclusion

Discuss how this activity compares to actual data collecting and how the sampling techniques could be improved. What are the potential sources of error inherent in this experiment's design? What correlations exist between the physico-chemical factors plotted on your graph and the organisms encountered? How do student profiles compare to each other? What are advantages and disadvantages of different sampling techniques?

George I. Matsumoto © MBARI 1991

Siphonophore

Sources of Deep Sea Animal Images and Other Information

Web Sites

http://www.virtual-canyon.org
Refer to the Identification Guide located in the Control Room and in the Galley of the *Western Flyer*

http://www.discovery.com/stories/nature/creatures/creatures.html

http://bigjohn.bmi.net/yancey/
Click on "Deep-Sea Pages" at top of page

http://bonita.mbnms.nos.noaa.gov/sitechar/phys22.html
Site characterization for Monterey Bay National Marine Sanctuary

Slide Sets

Midwater animals and tools—20 slides for $15.00
Available from Monterey Bay Aquarium Research Institute
(To order, call MBARI at 831-775-1700.)

Benthic animals—20 slides for $15.00
Available from Monterey Bay Aquarium Research Institute
(To order, call MBARI at 831-775-1700.)

MBARI facilities and tools—20 slides for $15.00
Available from Monterery Bay Aquarium Research Institute.
(To order, call MBARI at 831-775-1700.)

DIVE MISSION CARDS

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 100 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 150 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 150 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 200 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 200 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 250 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 250 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 300 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 0 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 300 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION CARDS

DIVE MISSION
Complete a vertical transect of the water column from 50 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 200 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 250 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 300 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 100 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 250 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 300 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 150 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 200 meters to 300 meters. You may collect a total of ten samples.

DIVE MISSION
Complete a vertical transect of the water column from 200 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION CARDS

DIVE MISSION

Complete a vertical transect of the water column from 200 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 350 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 300 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 200 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 300 meters to 400 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 350 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 200 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 300 meters to 450 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 350 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 200 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 300 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 350 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 200 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 250 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 300 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 350 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION CARDS / WATER SAMPLE CARDS

DIVE MISSION

Complete a vertical transect of the water column from 400 meters to 500 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 400 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 450 meters to 600 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 400 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 450 meters to 550 meters. You may collect a total of ten samples.

DIVE MISSION

Complete a vertical transect of the water column from 500 meters to 600 meters. You may collect a total of ten samples.

……

WATER SAMPLE

Depth: 0.0 meters
Pressure: 1.0 atmosphere
Temperature: 13.2° C
Salinity: 33.0 o/oo
Dissolved oxygen: 5.2 mL/liter

WATER SAMPLE

Depth: 0.0 meters
Pressure: 1.0 atmosphere
Temperature: 13.1° C
Salinity: 32.9 o/oo
Dissolved oxygen: 5.1 mL/liter

WATER SAMPLE

Depth: 50.0 meters
Pressure: 6.0 atmosphere
Temperature: 12.5° C
Salinity: 33.0 o/oo
Dissolved oxygen: 5.3 mL/liter

WATER SAMPLE

Depth: 0.0 meters
Pressure: 1.0 atmosphere
Temperature: 13.0° C
Salinity: 33.1 o/oo
Dissolved oxygen: 5.0 mL/liter

WATER SAMPLE

Depth: 0.0 meters
Pressure: 1.0 atmosphere
Temperature: 12.9° C
Salinity: 33.0 o/oo
Dissolved oxygen: 5.1 mL/liter

WATER SAMPLE

Depth: 50.0 meters
Pressure: 6.0 atmosphere
Temperature: 12.4° C
Salinity: 33.2 o/oo
Dissolved oxygen: 5.2 mL/liter

WATER SAMPLE CARDS

WATER SAMPLE
Depth: 50.0 meters
Pressure: 6.0 atmosphere
Temperature: 12.6° C
Salinity: 33.4 o/oo
Dissolved oxygen: 5.4 mL/liter

WATER SAMPLE
Depth: 100.0 meters
Pressure: 11.0 atmosphere
Temperature: 11.9° C
Salinity: 33.3 o/oo
Dissolved oxygen: 5.6 mL/liter

WATER SAMPLE
Depth: 150.0 meters
Pressure: 16.0 atmosphere
Temperature: 11.7° C
Salinity: 33.4 o/oo
Dissolved oxygen: 5.7 mL/liter

WATER SAMPLE
Depth: 50.0 meters
Pressure: 6.0 atmosphere
Temperature: 12.3° C
Salinity: 33.2 o/oo
Dissolved oxygen: 5.3 mL/liter

WATER SAMPLE
Depth: 100.0 meters
Pressure: 11.0 atmosphere
Temperature: 12.1° C
Salinity: 33.4 o/oo
Dissolved oxygen: 5.7 mL/liter

WATER SAMPLE
Depth: 150.0 meters
Pressure: 16.0 atmosphere
Temperature: 11.4° C
Salinity: 33.5 o/oo
Dissolved oxygen: 5.8 mL/liter

WATER SAMPLE
Depth: 100.0 meters
Pressure: 11.0 atmosphere
Temperature: 12.0° C
Salinity: 33.5 o/oo
Dissolved oxygen: 5.5 mL/liter

WATER SAMPLE
Depth: 150.0 meters
Pressure: 16.0 atmosphere
Temperature: 11.5° C
Salinity: 33.5 o/oo
Dissolved oxygen: 5.8 mL/liter

WATER SAMPLE
Depth: 200.0 meters
Pressure: 21.0 atmosphere
Temperature: 11.0° C
Salinity: 33.7 o/oo
Dissolved oxygen: 5.9 mL/liter

WATER SAMPLE
Depth: 100.0 meters
Pressure: 11.0 atmosphere
Temperature: 11.8° C
Salinity: 33.4 o/oo
Dissolved oxygen: 5.6 mL/liter

WATER SAMPLE
Depth: 150.0 meters
Pressure: 16.0 atmosphere
Temperature: 11.6° C
Salinity: 33.6 o/oo
Dissolved oxygen: 5.9 mL/liter

WATER SAMPLE
Depth: 200.0 meters
Pressure: 21.0 atmosphere
Temperature: 11.1° C
Salinity: 33.6 o/oo
Dissolved oxygen: 6.0 mL/liter

WATER SAMPLE CARDS

WATER SAMPLE
Depth: 200.0 meters
Pressure: 21.0 atmosphere
Temperature: 10.9° C
Salinity: 33.7 o/oo
Dissolved oxygen: 5.8 mL/liter

WATER SAMPLE
Depth: 250.0 meters
Pressure: 26.0 atmosphere
Temperature: 10.5° C
Salinity: 33.8 o/oo
Dissolved oxygen: 5.3 mL/liter

WATER SAMPLE
Depth: 300.0 meters
Pressure: 31.0 atmosphere
Temperature: 10.0° C
Salinity: 34.0 o/oo
Dissolved oxygen: 3.7 mL/liter

WATER SAMPLE
Depth: 200.0 meters
Pressure: 21.0 atmosphere
Temperature: 11.0° C
Salinity: 33.8 o/oo
Dissolved oxygen: 6.0 mL/liter

WATER SAMPLE
Depth: 250.0 meters
Pressure: 26.0 atmosphere
Temperature: 10.4° C
Salinity: 33.8 o/oo
Dissolved oxygen: 5.2 mL/liter

WATER SAMPLE
Depth: 300.0 meters
Pressure: 31.0 atmosphere
Temperature: 10.1° C
Salinity: 33.8 o/oo
Dissolved oxygen: 3.8 mL/liter

WATER SAMPLE
Depth: 250.0 meters
Pressure: 26.0 atmosphere
Temperature: 10.6° C
Salinity: 33.7 o/oo
Dissolved oxygen: 5.3 mL/liter

WATER SAMPLE
Depth: 300.0 meters
Pressure: 31.0 atmosphere
Temperature: 10.0° C
Salinity: 33.9 o/oo
Dissolved oxygen: 3.8 mL/liter

WATER SAMPLE
Depth: 350.0 meters
Pressure: 36.0 atmosphere
Temperature: 9.6° C
Salinity: 34.0 o/oo
Dissolved oxygen: 2.6 mL/liter

WATER SAMPLE
Depth: 250.0 meters
Pressure: 26.0 atmosphere
Temperature: 10.5° C
Salinity: 33.9 o/oo
Dissolved oxygen: 5.4 mL/liter

WATER SAMPLE
Depth: 300.0 meters
Pressure: 31.0 atmosphere
Temperature: 9.9° C
Salinity: 33.9 o/oo
Dissolved oxygen: 3.9 mL/liter

WATER SAMPLE
Depth: 350.0 meters
Pressure: 36.0 atmosphere
Temperature: 9.7° C
Salinity: 34.0 o/oo
Dissolved oxygen: 2.5 mL/liter

WATER SAMPLE CARDS

WATER SAMPLE
Depth: 350.0 meters
Pressure: 36.0 atmosphere
Temperature: 9.5° C
Salinity: 33.9 o/oo
Dissolved oxygen: 2.7 mL/liter

WATER SAMPLE
Depth: 400.0 meters
Pressure: 41.0 atmosphere
Temperature: 9.0° C
Salinity: 33.9 o/oo
Dissolved oxygen: 1.2 mL/liter

WATER SAMPLE
Depth: 450.0 meters
Pressure: 46.0 atmosphere
Temperature: 8.7° C
Salinity: 34.1 o/oo
Dissolved oxygen: 0.7 mL/liter

WATER SAMPLE
Depth: 350.0 meters
Pressure: 36.0 atmosphere
Temperature: 9.4° C
Salinity: 34.0 o/oo
Dissolved oxygen: 2.6 mL/liter

WATER SAMPLE
Depth: 400.0 meters
Pressure: 41.0 atmosphere
Temperature: 8.9° C
Salinity: 34.0 o/oo
Dissolved oxygen: 1.3 mL/liter

WATER SAMPLE
Depth: 450.0 meters
Pressure: 46.0 atmosphere
Temperature: 8.8° C
Salinity: 34.0 o/oo
Dissolved oxygen: 0.8 mL/liter

WATER SAMPLE
Depth: 400.0 meters
Pressure: 41.0 atmosphere
Temperature: 9.0° C
Salinity: 34.1 o/oo
Dissolved oxygen: 1.1 mL/liter

WATER SAMPLE
Depth: 450.0 meters
Pressure: 46.0 atmosphere
Temperature: 8.7° C
Salinity: 34.1 o/oo
Dissolved oxygen: 0.7 mL/liter

WATER SAMPLE
Depth: 500.0 meters
Pressure: 51.0 atmosphere
Temperature: 8.5° C
Salinity: 34.3 o/oo
Dissolved oxygen: 0.6 mL/liter

WATER SAMPLE
Depth: 400.0 meters
Pressure: 41.0 atmosphere
Temperature: 9.1° C
Salinity: 34.0 o/oo
Dissolved oxygen: 1.2 mL/liter

WATER SAMPLE
Depth: 450.0 meters
Pressure: 46.0 atmosphere
Temperature: 8.6° C
Salinity: 34.2 o/oo
Dissolved oxygen: 0.6 mL/liter

WATER SAMPLE
Depth: 500.0 meters
Pressure: 51.0 atmosphere
Temperature: 8.6° C
Salinity: 34.2 o/oo
Dissolved oxygen: 0.6 mL/liter

WATER SAMPLE CARDS

WATER SAMPLE

Depth: 500.0 meters
Pressure: 51.0 atmosphere
Temperature: 8.5° C
Salinity: 34.2 o/oo
Dissolved oxygen: 0.5 mL/liter

WATER SAMPLE

Depth: 550.0 meters
Pressure: 56.0 atmosphere
Temperature: 8.3° C
Salinity: 34.3 o/oo
Dissolved oxygen: 0.6 mL/liter

WATER SAMPLE

Depth: 600.0 meters
Pressure: 61.0 atmosphere
Temperature: 8.1° C
Salinity: 34.5 o/oo
Dissolved oxygen: 0.5 mL/liter

WATER SAMPLE

Depth: 500.0 meters
Pressure: 51.0 atmosphere
Temperature: 8.4° C
Salinity: 34.1 o/oo
Dissolved oxygen: 0.7 mL/liter

WATER SAMPLE

Depth: 550.0 meters
Pressure: 56.0 atmosphere
Temperature: 8.2° C
Salinity: 34.4 o/oo
Dissolved oxygen: 0.4 mL/liter

WATER SAMPLE

Depth: 600.0 meters
Pressure: 61.0 atmosphere
Temperature: 8.0° C
Salinity: 34.4 o/oo
Dissolved oxygen: 0.3 mL/liter

WATER SAMPLE

Depth: 550.0 meters
Pressure: 56.0 atmosphere
Temperature: 8.3° C
Salinity: 34.3 o/oo
Dissolved oxygen: 0.5 mL/liter

WATER SAMPLE

Depth: 600.0 meters
Pressure: 61.0 atmosphere
Temperature: 8.0° C
Salinity: 34.3 o/oo
Dissolved oxygen: 0.4 mL/liter

WATER SAMPLE

Depth: 550.0 meters
Pressure: 56.0 atmosphere
Temperature: 8.4° C
Salinity: 34.2 o/oo
Dissolved oxygen: 0.5 mL/liter

WATER SAMPLE

Depth: 600.0 meters
Pressure: 61.0 atmosphere
Temperature: 7.9° C
Salinity: 34.4 o/oo
Dissolved oxygen: 0.4 mL/liter

PHOTOGRAPHIC SURVEY CARDS

PHOTOGRAPHIC SURVEY
Depth: 0 meters
Common Name:
Bristlemouth
Scientific Name:
Cyclothone signata
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 50 meters
Common Name:
Market squid
Scientific Name:
Loligo opalescens
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 100 meters
Common Name:
Giant larvacean
Scientific Name:
Bathochordaeus charon
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 0 meters
Common Name:
Krill
Scientific Name:
Euphausia pacifica
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 50 meters
Common Name:
Fangtooth
Scientific Name:
Anoplogaster cornuta
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 100 meters
Common Name:
Crystal amphipod
Scientific Name:
Cystisoma fabricii
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 0 meters
Common Name:
Siphonophore
Scientific Name:
Nanomia bijuga
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 50 meters
Common Name:
Silver hatchetfish
Scientific Name:
Argyropelecus lychnus
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 100 meters
Common Name:
Cockatoo squid
Scientific Name:
Galiteuthis phyllura
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 0 meters
Common Name:
Blue Shark
Scientific Name:
Prionace glauca
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 50 meters
Common Name:
Pacific grenadier
Scientific Name:
Coryphaenoides acrolepis
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 100 meters
Common Name:
Black prince copepod
Scientific Name:
Gaussia princeps
Habitat: Midwater

PHOTOGRAPHIC SURVEY CARDS

PHOTOGRAPHIC SURVEY
Depth: 150 meters
Common Name:
Giant red mysid
Scientific Name:
Gnathophausia ingens
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 200 meters
Common Name:
Red octopus
Scientific Name:
Octopus rubescens
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 200 meters
Common Name:
Arrowworm
Scientific Name:
Pseudosagitta sp.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 150 meters
Common Name:
Cock-eyed squid
Scientific Name:
Histioteuthis heteropsis
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 200 meters
Common Name:
Hammerhead larvacean
Scientific Name:
Oikopleura villafrancae
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 250 meters
Common Name:
Pacific sergestid
Scientific Name:
Sergestes similis
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 150 meters
Common Name:
Rabbit-eared comb jelly
Scientific Name:
Kiyohimea usagi
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 200 meters
Common Name:
Pacific dreamer anglerfish
Scientific Name:
Oneirodes acanthias
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 250 meters
Common Name:
Dinner plate medusa
Scientific Name:
Solmissus marshalli
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 150 meters
Common Name:
Nermertean worm
Scientific Name:
Nectonemertes sp.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 200 meters
Common Name:
Sesquipedalian siphonophore
Scientific Name:
Praya dubia
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 250 meters
Common Name:
Northern lampfish
Scientific Name:
Stenobrachius leucopsarus
Habitat: Midwater

PHOTOGRAPHIC SURVEY CARDS

PHOTOGRAPHIC SURVEY
Depth: 300 meters
Common Name:
Lobed comb jelly
Scientific Name:
Bathocyroe fosteri
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 350 meters
Common Name:
Tomopterid
Scientific Name:
Tomopteris pacifica
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 400 meters
Common Name:
Pacific viperfish
Scientific Name:
Chauliodus macouni
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 300 meters
Common Name:
Blackdragon
Scientific Name:
Idiacanthus antrostomus
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 350 meters
Common Name:
Midwater jelly
Scientific Name:
Atolla vanhoeffeni
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 400 meters
Common Name:
Dragonfish
Scientific Name:
Tactostoma macropus
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 300 meters
Common Name:
Pallid eelpout
Scientific Name:
Lycodapus mandibularis
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 350 meters
Common Name:
Sword-tail squid
Scientific Name:
Chiroteuthis calyx
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 400 meters
Common Name:
Bloody belly
Scientific Name:
genus nov.; species nov.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 300 meters
Common Name:
Midwater eelpout
Scientific Name:
Nectonemertes sp.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 350 meters
Common Name:
Silky medusa
Scientific Name:
Colobonema sericeum
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 400 meters
Common Name:
Sperm whale
Scientific Name:
Physeter macrocephalus
Habitat: Midwater

PHOTOGRAPHIC SURVEY CARDS

PHOTOGRAPHIC SURVEY
Depth: 450 meters
Common Name:
Northern elephant seal
Scientific Name:
Mirounga angustinostris
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 500 meters
Common Name:
Vampire squid
Scientific Name:
Vampyroteuthis infernalis
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 550 meters
Common Name:
Sea gooseberry
Scientific Name:
Pleurobrachia bachei
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 450 meters
Common Name:
Gulper eel
Scientific Name:
Saccopharynx lavenbergi
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 500 meters
Common Name:
Halyard siphonophore
Scientific Name:
Apolemia uvaria
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 550 meters
Common Name:
Opah
Scientific Name:
Lampris guttatus
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 450 meters
Common Name:
Filetail catshark
Scientific Name:
Parmaturus xaniurus
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 500 meters
Common Name:
Owlfish
Scientific Name:
Bathylagus milleri
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 550 meters
Common Name:
Black-eyed squid
Scientific Name:
Gonatus onyx
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 450 meters
Common Name:
Comb jelly
Scientific Name:
Beroe forskalii
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 500 meters
Common Name:
Rocketship siphonophore
Scientific Name:
Lensia sp.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Depth: 550 meters
Common Name:
Slender snipe eel
Scientific Name:
Nemichthys scolopaceus
Habitat: Midwater

PHOTOGRAPHIC SURVEY CARDS

PHOTOGRAPHIC SURVEY
Depth: 600 meters
Common Name:
Blackdevil anglerfish
Scientific Name:
Melanocetus johnsonii
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Substrate: variable
Common Name:
Spot prawn
Scientific Name:
Pandalus platyceros
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Variable
Common Name:
Brittlestar on sea pens
Scientific Name:
Asteronyx loveni
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Depth: 600 meters
Common Name:
Shining tubeshoulder
Scientific Name:
Sagamichthys abei
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Substrate: Walls and rocks
Common Name:
Glass sponge
Scientific Name:
Acanthascus platei
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Seep site
Common Name:
Cold seep clam
Scientific Name:
Calyptogena kilmeri
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Depth: 600 meters
Common Name:
Dollar hatchetfish
Scientific Name:
Sternoptyx sp.
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Substrate: Rocks on bottom and wall
Common Name:
Mushroom soft coral
Scientific Name:
Anthomastus ritteri
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Rocks on bottom and wall
Common Name:
Basketstar
Scientific Name:
Gorgonocephalus eucnemis
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Depth: 600 meters
Common Name:
California headlightfish
Scientific Name:
Diaphus theta
Habitat: Midwater

PHOTOGRAPHIC SURVEY
Substrate: Variable
Common Name:
Brown cat shark
Scientific Name:
Apristurus brunneus
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Variable
Common Name:
Spotted ratfish
Scientific Name:
Hydrolagus colliei
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Rocks on bottom and wall
Common Name: Predatory tunicate
Scientific Name: *Megalodicopia hians*
Habitat: Benthic

PHOTOGRAPHIC SURVEY
Substrate: Carbonate shelfs
Common Name: Brachiopod
Scientific Name: *Laqueus californianus*
Habitat: Benthic

WILD CARD
Water alarm occurs. Make a careful ascent to the surface and terminate dive.

WILD CARD
Rough weather causes cancellation of your dive.

WILD CARD
A strong current causes you to miss two of your water samples.

WILD CARD
All systems fail. Settle on the bottom and wait (up to 80 hours) to be rescued.

WILD CARD
You encounter a giant squid and receive permission to change your dive plan. You may now observe and photograph it.

WILD CARD
Dive supervisor gives you permission to extend your dive time one hour. Collect two additional samples.

WILD CARD
Ideal weather allows you to make an additional dive. Select another dive mission.

WILD CARD
Clear water and calm conditions result in an ideal dive. Dive supervisor gives you permission to extend dive time two hours. Collect four additional samples.

DIVE PLAN AND PRE-DIVE LOGISTICS SHEET

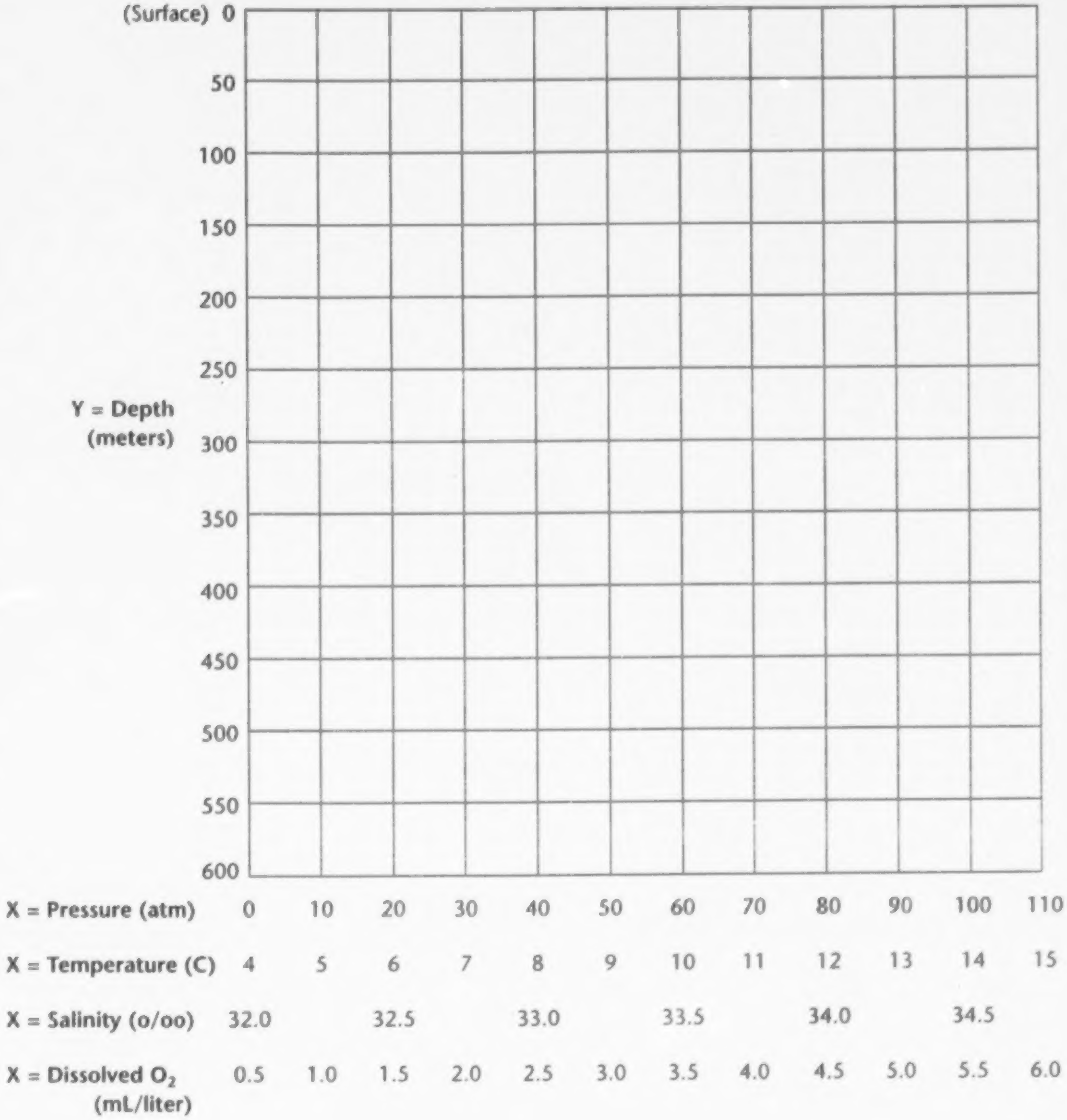
Dive Plan

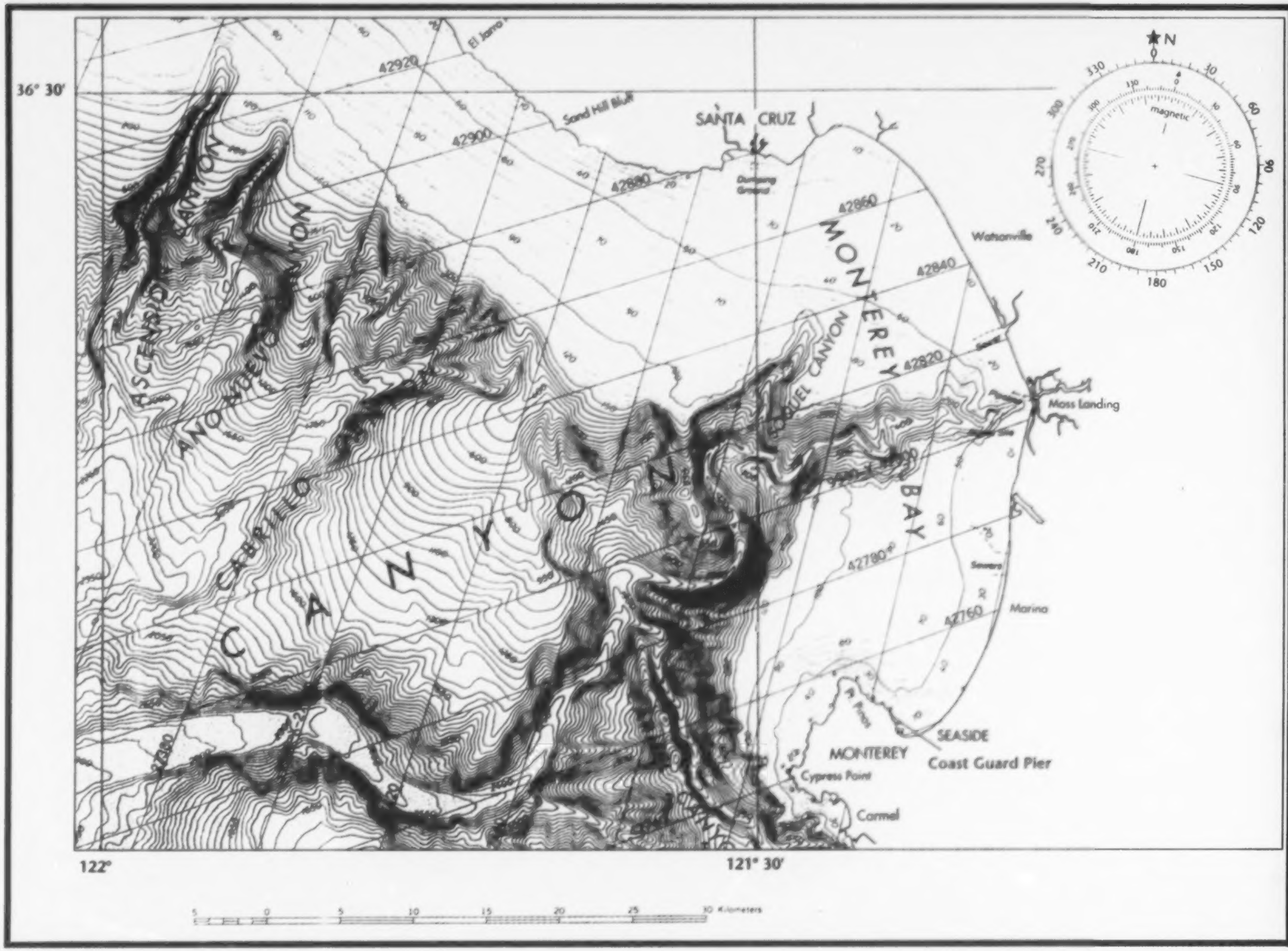
Pre-Dive Logistics

Sustainable Seas Expeditions

GRAPH GRID

VARIABILITY OF PHYSICAL FACTORS IN VERTICAL TRANSECT




N
magnetic
330
30
60
90
120
150
180
210
240
270
300
36° 30'
122°
121° 30'
El Jarro Pt
Sand Hill Bluff
SANTA CRUZ
Dumping Ground
Watsonville
Moss Landing
Marina
Seaside
SEASIDE
MONTEREY
Coast Guard Pier
Cypress Point
Carmel
MONTEREY BAY
ASCENSION CANYON
ANO NUEVO CANYON
CABRILLO CANYON
MONTEREY CANYON
SOQUEL CANYON
42920
42900
42880
42860
42840
42820
42780
42760
5
0
5
10
15
20
25
30 Kilometers

MONTEREY BAY NATIONAL MARINE SANCTUARY CHART

ACTIVITY

Planning Your SSE Mission

Guiding questions

If you were selected as a DeepWorker pilot, what would your mission be? How would your study meet the goals of *Sustainable Seas Expeditions* and contribute to our understanding of the sea?

Discussion

The main goal of *Sustainable Seas Expeditions* is to explore, conduct research in, and promote conservation of the nation's 13 marine sanctuaries. Scientists conduct investigations for a wide variety of reasons. They may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.

© Richard Harrison

Ctenophore

By developing their own projects, students will gain an understanding of what is involved in conducting a scientific investigation at sea. Students select a sanctuary, then design a research project that includes a hypothesis, background information, materials needed, and methods of conducting the investigation. Teachers may select the top three student projects to be submitted to *Sustainable Seas Expeditions*. Exemplary projects will be posted on the *Expeditions* web site; a select few may be considered for future *Expeditions* investigations.

Materials

- ☐ **Goals of *Sustainable Seas Expeditions*,** one for each student or group
- ☐ **Project Description** sheet (blank), one for each student or group
- ☐ **National Marine Sanctuary Sites. Exploring for Answers** and **Meet DeepWorker** background information.
- ☐ Access to the Internet (optional)

1 Procedure

Using the **Exploring—For Answers Background Information** sheet as a guide, begin a discussion on exploration of the seas. Explain that the ocean covers nearly three-fourths of the Earth's surface (about 71 percent), yet only about one

percent of the seas have been explored. To visually demonstrate this, fold a piece of 8 1/2 x 11-inch paper into fourths, explaining it represents planet Earth of which three-fourths is ocean. Drop a quarter on the "ocean" portion of the paper to illustrate the amount of ocean that has been explored.

2 Continue the discussion, engaging your students in a conversation about why we explore and why it is important to learn more. Lead them into further discussion about what they'd like to learn more about. Ask them if they were selected as a DeepWorker pilot, what would they want to study? How would their study contribute to our understanding of the sea? Explain that they will work in small groups or alone to develop a scientific investigation using the capabilities of DeepWorker. Using the teacher's version of the **Project Description** sheet as a model, ask students what kinds of information they would need to include in planning their investigations.

3 As students develop their investigation ideas, they will need to decide on their research topic, identify a study site, and select methods to collect data. Many *Sustainable Seas Expeditions* projects are site characterizations: surveying organisms and physical factors of a site. Others employ transects as ways to document species presence and abundance (for example, the vertical transect activity in these materials). Students may refer to the *Sustainable Seas Expeditions* web site at www.sustainableseas.noaa.gov to see what scientists are finding during their expeditions or contact a sanctuary they are interested in to learn more about the issues they are facing.

4 Students' proposals for *Sustainable Seas Expeditions* projects must stay within the capabilities of DeepWorker and meet the goals of this program. Give students copies of the **Meet DeepWorker** background information sheet, the **Goals of *Sustainable Seas Expeditions*** handout, and **National Marine Sanctuary Sites** background information to use as guidelines when developing their investigations.

5 While students are developing their investigations, engage them in discussions about the materials and methods they propose to use. The guiding questions on the **Project Description** sheet suggest topics for these discussions.

6 Give students the blank **Project Description** handout and have them begin to outline their investigations. Remind them to review the goals of *Sustainable Seas Expeditions* and describe how their investigations meet these goals.

7 Have students clearly define their research project, formulate a testable hypothesis, and describe the materials and methods that will be used. Ask them to clearly demonstrate how their investigation is connected to the scientific concepts guiding their hypotheses. How will their investigation contribute to our understanding of the seas?

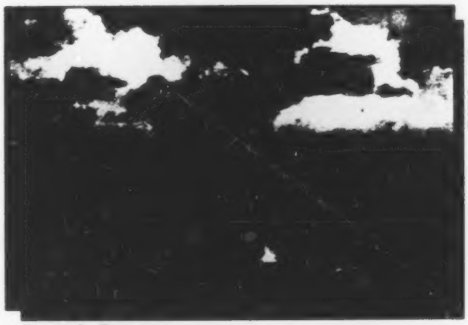
8 While students are researching background information about their area of study, encourage them to access a variety of sources, sort them for relevancy, and identify complexities and discrepancies resulting from the synthesis of many sources. Make sure students reference the sources used.

9 Once students have a rough draft of their investigation, have them review it with a classmate.

10 Have students revise their plans, then prepare a final presentation to explain their proposals. Have them include graphs, maps, charts, and models as needed. Students can use the **Project Description** as a rubric to score each others' presentations.

11 If interested, have students (or yourself) select the top three student projects which best follow the guidelines. These projects may be submitted for consideration as projects for the *Sustainable Seas Expeditions* web site or possible future *Expeditions*. Send them to:

Sustainable Seas Expeditions
Attention: Student Projects
735 State Street, Suite 617
Santa Barbara, California 93101


© Wolcott Henry

Fagatele Bay

Filling in the Project Description For Teachers

PROJECT TITLE: The title should describe the proposed project

HYPOTHESIS: Is the hypotheses testable?

INTRODUCTION: After visiting the web site of their selected sanctuary or talking to the research coordinator, have students give an overall description of their scientific investigations including: What research has been done? What do we already know? What scientific concepts are being investigated? (For example, predator and prey relationships, change over time, competition, etc.)

If students are studying organisms, ask them to discuss relationships among the organisms and their physical surroundings. What physical conditions does the organism favor? Does the organism's predators and prey favor the same conditions? What kinds of patterns can be seen among organisms, physical conditions, and their geographic location? How does this contribute to our understanding of the seas?

How does the project meet the goals of *Sustainable Seas Expeditions*?

LOCATION: In which sanctuary is the study site located? What is the latitude and longitude? What types of habitat are found at their study site?

MATERIALS: What tools do students need to collect data (cameras, sampling tools, instruments to take temperature, and other measurements)?

Have students make a complete list of all supplies that will be needed. How will the tools be deployed? (For example, how do you take a water sample?) If the tools don't exist, have students propose a design for what they could use.

METHODS: What kinds of sampling methods will students use in their investigation (photos, video, specimen collection, transect counts, and so on)? What are the pros and cons of different methods?

Will students take samples? How many? Where and when will they take them?

Does the investigation require samples be taken during a certain time of day or night? During a particular season?

How will students get the samples back to the surface?

How will the samples be analyzed?

What sources of error are inherent in the experimental design?

How long will the dives be? How many dives are required?

Are students recording their data with respect to where it is spatially? (For example, if doing a vertical transect, at what depth are they collecting data; or if doing a horizontal transect, where along the transect are they collecting data?)

REFERENCES: Have students include a variety of sources including scientific papers, journals, the Internet, and books.

Which references are most relevant to student investigations?

Did they find any discrepancies as a result of consulting multiple resources? Discuss the importance of primary literature as an accurate source of information.

This proposal was submitted by the students of Mike Guardino's marine research class at Carmel High School, California.

PROJECT TITLE: Comparison of Organisms Inside and Outside the Boundaries of a No-take Zone in Monterey Bay National Marine Sanctuary

HYPOTHOSIS: More species exist in a no-take zone compared to an area where fishing and other harvesting practices are permitted.

INTRODUCTION: A number of marine ecological reserves have been designated along the California coast including Pt. Lobos Reserve in NOAA's Monterey Bay National Marine Sanctuary. This reserve, designated a "no-take" zone, does not allow commercial and recreational harvesting of natural resources. This higher degree of protection gives scientists an opportunity to better understand the dynamics of a natural system that is free from consumptive exploitation. It can also be used as a natural laboratory to further the research, conservation, exploration, and educational goals of the marine sanctuary. Baseline data collected in a no-take zone can be used to help monitor the health of the marine sanctuary and make informed decisions about its management. Furthermore, the abundant, mature, reproductive stock in a no-take zone can help nearby populations of organisms recover from the pressures of overfishing (Yoklavich, 1997). Therefore, an entire national marine sanctuary surrounding a no-take zone can benefit from the specially-protected areas within it.

The Pt. Lobos Reserve was first established to protect terrestrial habitats along the shore. In 1960, 750 submerged acres were added to prevent further damage to, and allow for the recovery of, its unique marine community. After many years of heavy fishing pressure, including the commercial harvest of abalone, the Reserve now features the species abundance and diversity that is characteristic of a pristine kelp forest community (Pt. Lobos web site, 1999: www.pt-lobos.parks.state.ca.us/).

In addition to Pt. Lobos Reserve, other marine reserves have been established or are being considered in the nation's marine sanctuaries. These include areas in the Channel Islands National Marine Sanctuary and Florida Keys National Marine Sanctuary. A second reserve in Monterey Bay National Marine Sanctuary, Big Creek Ecological Reserve, was established in 1994.

It is hoped that the data gathered in this study will help demonstrate the importance of designating no-take zones within our national marine sanctuaries. It may take time to realize the benefits of these zones, but it will certainly be worth the wait as we witness their establishment and recovery.

LOCATION: Two sites will be surveyed, both within the Monterey Bay National Marine Sanctuary (36° N 122° W).

- — The Pinnacles (near Bluefish Cove) in Pt. Lobos Reserve
- — A similar area outside Pt. Lobos Reserve

MATERIALS: DeepWorker 2000, RV *MacArthur*, video camera with lasers, compass, bathymetric charts, precise and accurate tracking instrumentation.

METHODS: Conduct a video survey of the bottom topography and organisms both inside and outside the Pt. Lobos reserve. Perform a site characterization of the two areas that includes:

— a survey of the invertebrate species present; and
— a survey of fish species present, along with how many of each species are seen.

The results will be compared with existing bathymetric charts of Carmel Submarine Canyon to give an accurate description of the region's bottom topography and benthos.

A video camera fitted with lasers will be used to document the size of the organisms being photographed.

Depth of survey: Maximum of 300 meters
Number of dives: Two (one inside and one outside of Pt. Lobos Reserve)
Length of dives: 4-6 hours each

REFERENCES:

GIS Data of the Monterey Bay. Version 1. CD-ROM. Moss Landing: Monterey Bay Aquarium Research Institute, 1998.

Gotshall, D.W. (1989). *Pacific Coast Inshore Fishes*. Monterey: Sea Challengers.

Humann, P. (1996). *Coastal Fish Identification: California to Alaska*. Jacksonville: New World Publications.

Love, R.M. (1991). *Probably More Than You Want to Know About the Fishes of the Pacific Coast*. Santa Barbara: Really Big Press.

Yoklavich, M.M. and R.M. Starr, 1997. "Mapping Benthic Habitats and Ocean Currents in the Vicinity of Central California's Big Creek Ecological Reserve." *NOAA Technical Memorandum NMFS*.

Yoklavich, M.M., Z.J. Lobe, M. Nishimota, B. Daly, 1996. "Nearshore Assemblages of Larval Rockfishes and Their Physical Environment off Central California During an Extended El Niño Event 1991–1993." *Fishery Bulletin* 94:766–782.

GOALS OF *SUSTAINABLE SEAS EXPEDITIONS*

- Document systematically the different types of algae, plants, and animals that live in the 13 national marine sanctuaries and provide a baseline for determining the health and condition of these organisms;
- Increase the nation's ability to conserve the natural and cultural resources of the oceans. The emphasis, as the name of the program indicates, is on sustainability of ocean resources; and,
- Establish the utility of new submersibles, such as DeepWorker 2000, for enhancing ocean exploration and conservation.

© Kip Evans

Clown fish

Sustainable Seas • Expeditions •

PROJECT DESCRIPTION SHEET

PROJECT TITLE:

HYPOTHESIS:

INTRODUCTION:

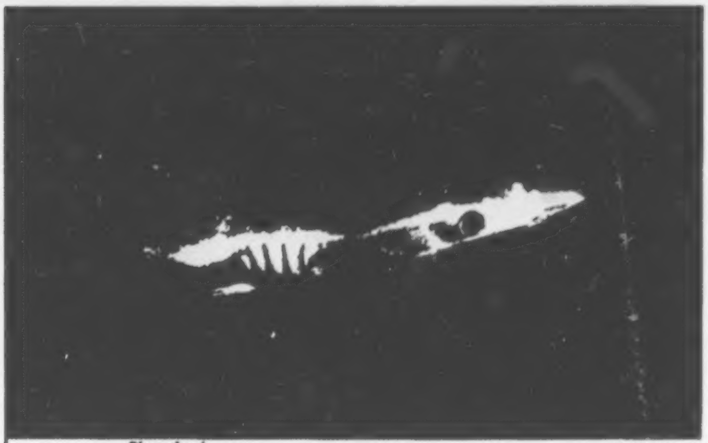
LOCATION:

MATERIALS:

METHODS:

REFERENCES:

Sustainable Seas Expeditions



Blue shark ©W. B. Evans

INVESTIGATION 4

Designing a Submersible

In this Investigation, students design submersibles that are neutrally buoyant and can travel through water. The first activity, "What is Neutral Buoyancy?," introduces the concept of neutral buoyancy, a key feature of DeepWorker 2000 and your students' designs. The second activity provides an opportunity to understand some of the chemistry behind DeepWorker's air purification system.

BACKGROUND INFORMATION

Meet DeepWorker

ACTIVITIES

What is Neutral Buoyancy?
Purifying the Air for DeepWorker Pilots
Design a Submersible

LEARNING OBJECTIVES

Students will:

- Define neutral buoyancy in their own words;
- Describe the chemistry behind purifying air for DeepWorker pilots;
- Describe some of the limitations scientists face when exploring the sea;
- Design a neutrally buoyant submersible capable of traveling through water.

STANDARDS

Science Education Standards
Developing abilities in technological design

Developing understandings about science and technology

ACTIVITY

What Is Neutral Buoyancy?

Guiding Question

What is neutral buoyancy and how does it affect a submersible's design?

Discussion

Density is a basic property of matter that measures the amount of mass of an object per unit volume (D = M/V). The density of freshwater is $1 g/cm^3$; the density of seawater is greater and varies considerably depending upon salinity and temperature. (For seawater with a salinity of 34.5 parts per thousand and a temperature of 15° C, the density is $1.025 g/cm^3$). In the ocean, solids are generally more dense than seawater. They tend to sink while gases are less dense and tend to rise. Water has an unusual property: its solid phase (ice) is less dense than most other solids, enabling it to float in liquid water. Buoyancy is the tendency of a fluid (gas or liquid) to exert an upward force on an object that is submerged in it. An object that is positively buoyant will float, one that is negatively buoyant will sink, while a substance that is neutrally buoyant displaces a quantity of matter of equal density. An object placed in seawater is more buoyant than the same object placed in freshwater. This is because the dissolved salts in seawater cause the water to be more dense.

The volume of freshwater displaced by an object can be used to determine the mass required to make it neutrally buoyant. Remember that:

$$1 \text{ mL } H_2O \text{ @ } 4° C = 1 cm^3 = 1 \text{ gram.}$$

Materials

- ☐ Lead shot
- ☐ 13 x 100 mm test tube
- ☐ #00 rubber stopper
- ☐ Milligram balance
- ☐ 100 milliliter (mL) graduated cylinder
- ☐ Water
- ☐ Indelible marker

Procedure

This activity may be used as a lab or demonstration.

1 Carefully measure freshwater into a 100 mL graduated cylinder so the bottom of the meniscus is precisely on the 80.0 mL line when viewed at eye level.

2 Mass a clean, dry 13 x 100 mL test tube and #00 rubber stopper on a milligram balance.

3 Add enough lead shot to the test tube (about half full) to make it negatively buoyant. Seal it with a tightly-fitting rubber stopper. Make a mark on the outside of the glass to record how far the stopper is inserted into the test tube.

4 Gently slide the test tube, stopper end down, into the graduated cylinder by tilting the glassware to one side.

5 Read the new volume in the graduated cylinder and determine the amount of water that has been displaced by the sealed test tube. Be sure no air bubbles have been trapped before taking this measurement. (Ask students why this is important: the trapped air displaces water, giving an inaccurate measurement.) Subtract the initial water volume (80.0 mL) from the (greater) final volume and convert to mass in grams.

6 Pour out the water and remove the weighted test tube from the graduated cylinder. Empty the test tube and replace the rubber stopper to the same mark on the glass. Refill the graduated cylinder to the 80.0 mL line and drop the empty tube in with the stopper end down. What volume does this positively buoyant object displace?

7 Remove the test tube again and add just enough lead shot to equal the mass of the displaced water. Refill the graduated cylinder with water to the 80.0 mL line and slide the neutrally buoyant test tube back in. Does the tube now rest in the water column rather than sink or float? Make any adjustments necessary to achieve neutral buoyancy.

Data and Calculations:

Mass of test tube and stopper = ____g

Final volume (____mL) - initial volume (80.0 mL) = H_2O volume displaced (_____mL)

Mass of displaced water (1 mL = 1g) = ____g

Conclusion

Compare what would happen if the same activity were done using seawater at 4°C. How would the shot weight need to be adjusted in seawater? Guide the discussion to consider how neutral buoyancy relates to submersibles, how students might address this in their designs, and how this feature benefits research.

ACTIVITY

Purifying the Air for DeepWorker Pilots

Guiding Question

How is the air in DeepWorker continually purified for pilots?

Discussion

The DeepWorker 2000 submersible uses "re-breather" technology to chemically remove carbon dioxide generated from aerobic respiration and a pair of high pressure cylinders to replenish the oxygen gas metabolized by aerobic respiration. This lab allows students to calculate the volume of carbon dioxide gas that can be removed from DeepWorker's cabin by the absorbent chemical "Soda-Lime." Soda-Lime, which is a mixture of caustic soda and lime [NaOH and $Ca(OH)_2$], is a chemical scrubber used to remove carbon dioxide from the air that has been expired by the pilot. SodaSorb® (the brand of soda-lime used by DeepWorker) is manufactured by the W.R. Grace Company in the United States. SodaSorb® consists of 70–80% $Ca(OH)_2$, 16–20% H_2O, 1–2% NaOH, and 0–1% KOH.

The mechanism for this exothermic reaction is:

$$H_2O(l) + CO_2(g) \longrightarrow H_2CO_3(aq)$$
$$2NaOH(s) + H_2CO_3(aq) \longrightarrow Na_2CO_3(s) + 2H_2O(l)$$
$$Ca(OH)_2(s) + H_2CO_3(aq) \longrightarrow CaCO_3(s) + 2H_2O(l)$$

There is a net production of three H_2O molecules for every molecule of CO_2 absorbed. Some chemical absorbents employ an indicator that changes color when the reactant is exhausted. The ethyl violet indicator in SodaSorb® changes from white to purple when the chemical can absorb no additional CO_2.

When a person breathes, 0.82L of CO_2 is exhaled for every liter of oxygen inhaled. An oxygen generation system should either produce a larger volume of O_2 than the volume of CO_2 consumed or make-up for the difference with a supplemental oxygen supply. A gas "regulator" is used to deliver oxygen to DeepWorker's cabin at the proper rate. Pressure gauges monitor the supply of O_2 gas in DeepWorker's twin cylinders.

The temperature of the absorbent influences the effectiveness of the reaction. SodaSorb® works much better in the relatively warm cabin of DeepWorker.

Materials

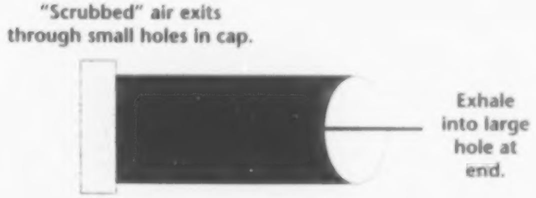
- ☐ Safety equipment (rubber gloves and eye protection)
- ☐ SodaSorb® (To order by phone, call 1-800-GET-SODA.)
- ☐ Timer
- ☐ Milligram balance

- ☐ Spirometer
- ☐ Gas collecting device (see illustration below)
- ☐ Calculator

Procedure

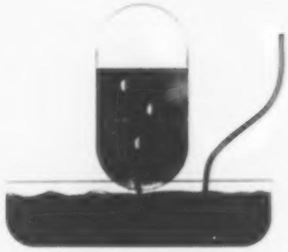
This activity may be used as a lab or demonstration.

1 Mass out 1.000 gram of SodaSorb® on a milligram balance and place it in a gas collecting device. Be careful to avoid packing the solid too tightly and be certain not to breathe the dust.


"Scrubbed" air exits through small holes in cap.
Exhale into large hole at end.

DEVICE USED TO COLLECT EXPIRED BREATH THAT CONTAINS CHEMICAL ABSORBENT.

2 Determine the tidal volume of gas that you produce in one minute by exhaling into a spirometer. An adequate homemade spirometer can be constructed with an overturned bottle of water, a dish pan, and a length of rubber hose.



HOMEMADE SPIROMETER

3 Begin exhaling at a normal rate into the gas collecting device and use a timer to determine how long you can continue before the ethyl violet indicator in the SodaSorb® turns purple. Assume that the chemical is exhausted at the first sign of a color change.

4 Determine the volume of gas that you exhaled by multiplying the time in minutes by the volume produced per minute.

5 Given that the average person at rest has 3.6 percent CO_2 (g) by volume in their expired breath, calculate the volume of CO_2 (g) that was absorbed by the SodaSorb®.

Data and Calculations

Volume of expired breath per minute:
______ liters

Time elapsed before indicator changes:
________ minutes

Volume of CO_2 absorbed per gram of SodaSorb®: ___________

ACTIVITY

Designing a Submersible

Guiding Question

How does a submersible's design address the limitations inherent to exploring the sea?

Discussion

The *Sustainable Seas Expeditions* will use a small submersible to explore, conduct research in, and promote conservation of the nation's 13 marine sanctuaries. This one-person vehicle must be simple enough to operate so pilots may complete their mission, yet sophisticated enough to safely reach depths of up to 600 meters (2,000 feet). By researching, constructing, and testing a small scale model prototype of a submersible, students will discover some of the design characteristics that make this vehicle so important to ocean exploration.

Materials

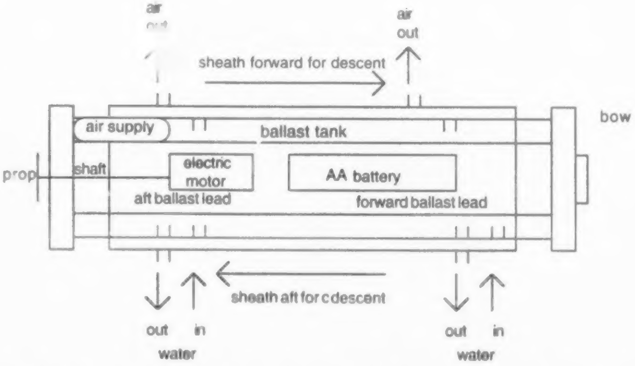
- ☐ A small aquarium (25 cm deep, 25 cm wide, 50 cm long), child's pool, or other container filled with clear, fresh water at ambient room temperature for testing submersibles
- ☐ **Submersible Specifications** handout, one for each group
- ☐ *Sustainable Seas Expeditions* poster
- ☐ Copy of **Meet DeepWorker Background Information** for each group
- ☐ Materials for submersibles such as PVC pipe, batteries, and propellers to be determined by student teams

Procedure

1 Tell students that their goal is to work with a classmate to design, build, and test a submersible prototype that is neutrally buoyant and can travel through water. A small aquarium or other container, filled with clear, fresh water at ambient room temperature, will be available to test and demonstrate their submersibles.

2 Explain to students that their submersibles must meet certain specifications. Give them the **Submersible Specifications** and copies of the **Meet DeepWorker Background Information** sheet.

3 Set a date for students to demonstrate and explain their submersibles with each other, including what worked, what didn't work, and how they redesigned their vehicle accordingly.



Sample Student Design: Pressure hull of PVC pipe with sealed end caps inside ballast hull. The submarine descends when soft ballast tanks are flooded with water and ascends when ballast is blown (air replaces water). Hard ballast of lead shot is located inside pressure hull. When outer plastic trim sheath moves forward, air escapes from top vents. When sheath moves aft, water escapes from bottom vents as ballast air supply ruptures.

SUBMERSIBLE SPECIFICATIONS

Your submersible prototype must meet the following specifications:

- It must displace at least .250kg of fresh water when fully submerged and can be no longer than 20cm from bow to stern with a beam (width) or height no greater than 20cm.
- It must be neutrally buoyant.
- It cannot be directly touched after it is deployed into the "ocean." Remote controls or tether lines may be used to operate controls on the submersible. A transducer may be deployed into the "ocean."
- The submersible must be built by you "from scratch"; for example, a commercial submarine retrofitted for this activity is not allowed.
- You and your partner will provide all materials for your submersible. It is not necessary to spend a lot of money to build a successful prototype.
- Your device must be safe.

Keep a Log

Keep a log of your activities. As part of the project, write a detailed description of your research and development, including what worked, what didn't work, and how you revised your design accordingly. Include a schematic, an explanation of all systems (ballast, steering, propulsion, remote control), and a bibliography. Use at least five references total from a variety of sources: journal articles, books, and web sites on the Internet. Include references to these sources as part of your written work.

Supplies and Where to Get Them

Rudders, hydroplanes, thrusters, and propellers should be considered in your design as part of the propulsion system. Batteries, electric motors, elastic bands, teacher-approved chemical reactions, compressed gas (air or carbon dioxide only), and lead shot for ballast are possible methods you may use to power your submersible and achieve neutral buoyancy. Care should be taken to ensure that thruster propellers are not a hazard. PVC pipe and plastic containers are possible materials for the frame of your submersible. All of the materials listed here are available in local hobby and hardware stores. You may already have some materials at home.

For More Information

Web sites	Submarine Kits: www.32ndparallel.com/
	Electronics & Hardware for Model Submarines: www.rcboats.com/
	Ideas for Homebuilt Submarines: www.webcom.com/sknkwrks/submarin.htm

Sustainable Seas Expeditions

Appendix 1: 1999–2000 Expeditions Schedule

NOTE: Learn about each of these *Expeditions* on-line:
http://sustainableseas.noaa.gov

1999

APRIL 16–APRIL 25	Gulf of the Farallones National Marine Sanctuary
APRIL 27–MAY 6	Cordell Bank National Marine Sanctuary
MAY 9–MAY 22	Monterey Bay National Marine Sanctuary
MAY 25–JUNE 4	Channel Islands National Marine Sanctuary
JUNE 18–JUNE 29	Olympic Coast National Marine Sanctuary
JULY 8–JULY 13	Stellwagen Bank National Marine Sanctuary
JULY 26–AUGUST 6	Gray's Reef National Marine Sanctuary
AUGUST 16–AUGUST 28	Florida Keys National Marine Sanctuary
SEPTEMBER 1–SEPTEMBER 13	Flower Garden Banks National Marine Sanctuary

2000

JANUARY 10-JANUARY 25	Hawaiian Islands Humpback Whale National Marine Sanctuary
JUNE 5-JUNE 24, JULY 14-JULY 19	Channel Islands National Marine Sanctuary
JUNE 26-JULY 12	Monterey Bay National Marine Sanctuary
JULY 27-AUGUST 31, SEPTEMBER 1-17	West Florida Shelf and Florida Keys National Marine Sanctuary

Appendix 2: About the Ocean

The Sea's Water

Coverage

- The seven oceans cover 71% (360 million square kilometers) of the Earth's surface and contain 97% of the Earth's supply of water.
- Earth is actually covered by only one layer of water. Even though the ocean is broken up into seven ocean parts, all of them are connected, one flowing into another.
- There are 1,365,336,000,000,000,000,000 liters (361,200,000,000,000,000,000 gallons) of sea water in the ocean. If all that water were piled on top of the United States, the land would be submerged under 140 kilometers (88.2 miles) of water.

Temperature

- Almost all of the deep ocean is only a little warmer than freezing, 3.8° C (39° F).

Currents

- The Kuroshio Current, off the shores of Japan, is the fastest-moving ocean current on Earth. It can travel between 40 and 120 kilometers (25 and 75 miles) a day, 2-5 kilometers (1–3 miles) per hour, and extends some 1,000 meters (3,300 feet deep). The Gulf Stream moves nearly as fast.

Saltiness

- If the ocean's total salt content were dried, the salt would cover all of the continents to a depth of about 1.5 meters (5 feet).

Depth

- At the deepest point in the ocean, the pressure is more than 1,260 kilograms per square centimeter (8 tons per square inch). That's equivalent to one person trying to hold 50 jumbo jets.
- The average depth of the ocean is 4 kilometers (2.5 miles).
- The area of the Pacific Ocean exceeds that of all the land.
- The deepest spot in the ocean is in the Mariana Trench (W Pacific SW of Guam) at 11.7 kilometers (36,198 feet). It is so deep that if Mount Everest were to be placed here, its peak would still be one kilometer below the surface of the ocean.

Exploration

- The oceans are still relatively unexplored, to the extent that more is known about the surface of Venus than the bottom of the deepest seas.
- In 1976 one of the world's largest sharks, the megamouth, was seen for the first time; while the last five years has seen the discovery of a new species of beaked whale off the South American coast.

Life in the Sea

- There may be as many as 18 million diatoms in a cubic meter of sea water.
- In the world's oceans are:

  — about 57 species of sea grasses
  — less than 1,000 species of cephalopods (squids, octopi, and pearly nautiluses)

  - more than 1,400 species of sea anemones
  - about 1,500 species of brown algae
  - more than 6,000 species of echinoderms—sea stars, sea urchins, sea cucumbers, and sea lilies
  - about 13,000 species of fishes
  - about 50,000 species of molluscs
- Two-thirds of the phyla, the major grouping below the kingdom level, are exclusively or dominantly marine.
- It is widely believed that the cheetah is the fastest creature on Earth, but the sailfish (a relative of the tuna and a highly prized sports fish) has been clocked at 110 kilometers (68 miles) per hour!

Fisheries

- Global fish consumption exceeds that of cattle, sheep, poultry or eggs, and is the biggest source of wild or domestic protein in the world.
- 86% of fish landings in 1989 were marine.
- 15 of the world's 17 largest fisheries are overfished or in trouble.

Health of the Sea

- Less than 30% of the coral reefs in Japan, Philippines, and Costa Rica are in good or excellent condition.
- The Great Auk, Steller's Sea Cow, Panamanian Fire Coral, San Diego Mud Snail, and Eelgrass Limpet are now extinct.

People and the Sea

- Oceans, although we may not realize it, are of great importance for all life (including people) on Earth. They provide food, resources, transportation, and recreational activities, and for these reasons should be treated with respect and care.
- While forests have been called the "lungs of the world," the oceans and seas also absorb huge quantities of carbon dioxide, thereby helping to regulate the Earth's climate. Changes in the winds and sea currents in the Pacific Ocean, for example, can be responsible for droughts and flooding across the southern hemisphere and possibly even further afield.
- Sewage, pulpmill wastes, fertilizers, soaps, detergents, radioactive wastes, synthetic fibers, plastics, oils, tars, greases, and insecticides are all pollutants man has placed in our Earth's oceans. We can help lessen the waste by recycling and buying less harmful, more environmentally-safe products.

Sources: National Oceanographic Data Center, Ocean Voice International, BBC Online

Glossary

Abyssal: referring to the deep sea or abyss

Bank: an undersea elevation rising from the continental shelf

Bathymetry: the measurement of depths of water in oceans, seas, and lakes

Bay: a small body of water set off from the main body, an inlet of the sea usually smaller than a gulf

Benthic: near or on the bottom

Canyon: a deep narrow valley with steep sides and often with a stream flowing through it

Cape: a point or extension of land jutting out into water as a peninsula or point

Continental Shelf: an old, wave-cut terrace gently sloping seaward

Continental Slope: beyond the shelf, the slope descends more steeply into the ocean shelf

Creek: a stream of water smaller than a river, often a tributary to a river

Davidson Current: warm ocean current flowing northward between the shoreline and the California Current along the West Coast of the U.S. during winter months

Degree: basic unit of measurement of latitude and longitude. There are 90 degrees of latitude between the equator and either pole, and there are 360 degrees of longitude that encircle the Earth

Detritus: particles of debris from decaying plants and animals

Ecology: scientific discipline involving interrelationships among organisms and their environments

Ecosystem: an ecological community together with its environment, functioning as a unit

Estuary: where river currents meet and are influenced by oceanic tides

Fan: (also called an alluvial fan) deposits from a stream that form gently sloping fan-shaped sediments, often seen at the base of a hill or gorge

Fathom: a unit of length equal to 6 ft and used principally in measuring depths in the marine environment

Geography: the science or the study of Earth and its life; a description of land, sea, air and the distribution of plant and animal life including people and cities

Geology: the science or the study of the Earth and its history as recorded in rocks

Gulf: a part of the ocean or sea extending into the land

Habitat: the environment where a particular plant or animal grows or is normally found

Hydrology: the science or the study of bodies of water, such as the measurement of flow in streams

Island: land surrounded on all sides by water and smaller than a continent

Knot: a unit of speed with a built in meaning per hour. One knot equals one nautical mile per hour, which is about 1.15 statute (or land based) miles per hour

Latitude: the angular distance north or south of the equator, measured in degrees along a meridian, a on a map or globe

Longitude: the angular distance on the Earth, as on a globe or map, east or west of the prime meridian at Greenwich, England, to the point on the Earth's surface for which the longitude is being ascertained, expressed in degrees, or in hours, minutes or second

Glossary

Meander: a turn or winding area of a stream

Monitoring: methods designed to detect changes in an ecosystem over time, such as changes in physical conditions, changes in distribution or abundance of organisms, or changes caused by human and natural events

Mount: a high hill

Midden: a refuse heap, a dump, especially referring to Indian kitchen middens

Nautical Mile: a unit of length used in sea and air navigation equal to 1.15 statute miles, 1,852 meters or 6,076 ft.

Oceanography: study of the physics, chemistry, biology and geology of the world's oceans

Peak: the top of a hill or mountain ending in a point

Pelagic: refers to the open water of the oceans, lacking association with the shore or the bottom

Plankton: plants and animals that swim weakly, or not at all, and drift with ocean currents

Point: a projecting area of land or a sharp prominence

Predator: an animal that kills and eats other animals

Range: a series of mountains

Remotely Operated Vehicle (ROV): an unmanned craft built to go beneath the ocean surface for the purpose of studying the marine environment. It is operated "remotely" from a ship

Ridge: (on land) a range of hills or mountains (on the ocean floor) an elongated elevation on the ocean bottom

River: a natural stream of water usually large and long

Sanctuary: a safe place of refuge and protection

Site Characterization: a study of an area that includes knowing the components of an ecosystem (such as algae, plants, animals, water temperature, etc.), the condition of the ecosystem in the past, its present condition, and enough understanding of how the ecosystem works to predict future conditions given certain variables

Sea Level: the level of the surface of the sea, a mid-point between the high and low tide

Seamount: a submarine mountain rising above the deep sea floor

Stakeholder: a citizen with a vested interest in a certain resource

Submarine Canyon: a long, narrow, steep-walled undersea valley

Submersible: a vehicle with or without a human inside that is capable of operating underwater and is used to explore the depths of the ocean

Substrate: any surface on which a plant or animal lives on, which a material sticks

Taxonomy: scientific classification of animals and plants

Transect: a monitoring research technique that marks a transverse along which measurements can be taken

Topography: a graphical representation of the physical features of a place or region on a map

Upwelling: a movement of nutrient-rich water to the surface, caused by wind-driven surface currents that carry water away from the continents

Valley: a long, low area of land usually between hills or mountains drained by a river

Watershed: a region or area connected by a body of water, rivers and drainage

Teacher Resources

NOAA's Marine Sanctuaries Division

1305 East-West Highway
SSMCY 11th Floor
Silver Spring, MD 20910
301.713.3125
301.713.0404 fax
http://www.sanctuaries.nos.noaa.gov

Brochures & Flyers:

National Marine Sanctuaries—Tour of the Sanctuaries general brochure—describes national marine sanctuary sites.

National Marine Sanctuaries Management Plan Revision—one-page background documents that describe the process to revise sanctuary management plans.

NOAA's National Marine Sanctuaries national map—map of the U.S. showing the location of the individual sanctuaries.

NOAA Backgrounder: National Marine Sanctuaries—one-page document describing the National Marine Sanctuaries Program.

Guide to Diving America's National Marine Sanctuaries—a comprehensive dive guide to the national marine sanctuaries (reprint from Rodale's Scuba Dive Magazine).

Maps:

NOAA Maps—http://mapfinder.nos.noaa.gov
NOAA Nautical Charts and Mapping—http://mapfindr.nos.noaa.gov
Ordering page for NOAA nautical charts—
http://chartmaker.ncd.noaa.gov/staff/prices.htm

Newsletters & Newspapers:

Sanctuary Watch —an electronic newsletter updated monthly focusing on interesting programs and activities from throughout the sanctuary system. http: //www.sanctuaries.nos.noaa.gov

NOAA News—a comprehensive electronic newsletter that covers news and activities from all of NOAA's programs. http://www.noaanews.noaa.gov

NOAA Report—a publication that covers topics about the National Marine Sanctuaries, and the other parts of NOAA such as National Weather Service and the National Marine Fisheries Service, among others. http://www.publicaffairs.noaa.gov/nr

Program Documents:

National Marine Sanctuaries Act (16 U.S.C. 1431 et seq.)—the authorizing legislation for the National Marine Sanctuaries Program.

Web Links:

NOAA's Classroom at Sea—http://classroomatsea.noaa.gov
NOAA Central Library Internet Locator—http://www.lib.noaa.gov/docs
NOAA Corps Fleet—www.nc.noaa.gov/fleet.html
NOAA Ocean—http://www.noaa.gov/ocean.html
NOAA Teacher at Sea Program—http://www.tas.noaa.gov

Sustainable Seas Expeditions

735 State Street, Suite 617
Santa Barbara, CA 93101
805.963.3238
805.963.2438 fax
http://sustainableseas.noaa.gov and
http://www.nationalgeographic.com/seas

Brochures & Flyers:

Sustainable Seas Expeditions general one-pager—a five-year project of the National Geographic Society and the National Oceanic and Atmospheric Administration made possible by the Richard and Rhoda Goldman Fund.

DeepWorker 2000 Submersible spec sheet—capabilities and specs of the DeepWorker 2000 single person, one-atmosphere submersible.

SSE Web site one pager—comprehensive description of the official SSE Web site, details about the mission log, photo gallery, live events, and other related Web offerings.

Dr. Sylvia Earle biography one pager—one page biography of the Sustainable Seas Expeditions Project Director and National Geographic Society Explorer-in-Residence.

Frequently Asked Questions (FAQ)—answers to many of the frequently asked questions about the Sustainable Seas Expeditions project, its goals and objectives and the DeepWorker 2000 submersible technology.

Books:

Wild Ocean—America's Parks Under the Sea—written by Dr. Sylvia A. Earle, published by the National Geographic Society, about the nation's marine sanctuaries.

Hello Fish and Dive!—children's book written by Dr. Sylvia A. Earle, published by the National Geographic Society.

Posters:

Sustainable Seas Expeditions poster—two-sided, four color poster, which includes information about the *Expeditions*, the NMSP, DeepWorker 2000 and a history of submersible technology.

Videos:

SSE general video—an 8-minute introduction video produced by the National Geographic Society (8 minutes).

1999 SSE Mission Highlights video—25-minute video that summarizes the West and East coast SSE mission highlights for the 1999 field season produced by the National Geographic Society.

SSE Education Highlights (April–July 1999) video—education highlights Student Ocean Summits, Sanctuary Teacher Workshops, and Teacher-in-the-Sea education programs.

Sustainable Seas Expeditions: Hawaiian Style video—15-minute summary video produced by the National Geographic Society.

Stickers:

SSE sticker—waterproof, vinyl oval stickers with the *Sustainable Seas Expeditions* logo.

K-12 Curricula:

SSE Teacher Resource Book Units 1 and 2 (reprinted October 2000)—a comprehensive teacher's guide including background information on the National Marine Sanctuary Program, the *Sustainable Seas Expeditions*, and DeepWorker submersible technology. Resource book includes student investigations targeted for high school students, which can be adapted for various grade levels, and it also includes an extensive list of sanctuary resources available to the general public.

Volunteer Opportunities:

Sustainable Seas Expeditions intern—undergraduate and graduate volunteer interns assist with administrative tasks and provide support for local outreach and media events.

Sustainable Seas Expeditions outreach event volunteer—attends local outreach and media events as a representative for the *Expeditions*, i.e. ocean fairs, press events, and student ocean summits.

Web Links:

Aquarius—http://www.uncwil.edu/nurc/aquarius
Consortium for Oceanographic Research & Education—http://core.cast.msstate.edu
Delta Oceanographic—http://azstarnet.com/~delta/index.html
Harbor Branch Oceanographic Institution—http://www.hboi.edu
JASON Project—http://www.jasonproject.org
Monterey Bay Aquarium—http://www.mbayaq.org
Monterey Bay Aquarium Research Institute (MBARI)—http://www.mbari.org
Mote Marine Laboratory—http://www.mote.org
NASA Quest—http://quest.arc.nasa.gov
National Geographic Society—http://www.nationalgeographic.com
National Marine Educators Association (NMEA)—http://www.marine-ed.org
National Marine Sanctuary Program—http://www.sanctuaries.nos.noaa.gov
National Oceanographic Partnership Program (NOPP)—http://core.cast.msstate.edu/NOPPpg1.html
National Ocean Service—http://www.nos.noaa.gov
National Undersea Research Program—http://www.nurp.noaa.gov
NOAA's Education Page—http://www.education.noaa.gov
Ocean Futures—http://oceanfutures.com
Reef Environmental Education Foundation (REEF)—http://www.reef.org
Sea Grant—http://www.nsgo.seagrant.org
The Bridge—http://www.vims.edu/bridge/index.html
The Cousteau Society—http://www.cousteausociety.org
Volunteering for the Coast—http://www.volunteer.nos.noaa.gov
Woods Hole Oceanographic Institution—http://www.whoi.edu

Visitor Centers:

National Geographic Society's Explorers Hall—a light weight life-size model of the DeepWorker 2000 submersible is on display as a permanent exhibit at Explorers Hall at the National Geographic Society, free of charge (1145 17th Street, NW, Washington, DC).

Channel Islands National Marine Sanctuary

113 Harbor Way
Santa Barbara, CA 93109
805.966.7107
805.568.1582 fax
http://www.cinms.nos.noaa.gov

Brochures & Flyers:

Channel Islands National Marine Sanctuary general brochure—sanctuary regulations.

Diving in the Channel Islands National Marine Sanctuary brochure—provides dive maps complete with information on anchorage, good diving spots, shipwrecks, and sea lion rookeries.

Things to Do brochure—gives an overview of different activities visitors can do within the Channel Islands National Marine Sanctuary , also provides information on pinnipeds, whales, dolphins, and sharks.

Shipwrecks of the Channel Islands brochure—provides a historical perspective about each shipwreck site within the Sanctuary. Included is a map showing each of the shipwreck sites, information on public transportation to the islands, what to do if divers discover a shipwreck and safety tips for boaters.

Marine Educators Regional Alliance (MERA) brochure—a complete list of all the organizations that comprise this regional alliance.

SAMSAP Information brochure—compilation of marine mammal sighting and vessel traffic surveys.

Research Programs in the Sanctuary one pager

Management Plan Review Process one pager

Marine Reserves one pager

Newsletters & Newspapers:

Alolkoy—this free quarterly newsletter provides highlights about current research projects and educational programs within the Channel Islands National Marine Sanctuary. Components of the *Alolkoy* are available on the Web at www.cinms.nos.noaa.gov.

Annual Reports—an overview of the Channel Islands National Marine Sanctuary programs and activities.

Living Journal—available on the CINMS web site. Sanctuary staff and interns write entries to offer perspective on different sanctuary projects and events as well as local and national events involving Sanctuary resources (http://www.cinms.nos.noaa.gov/publica.stm).

List Servs—currently available for Sanctuary Advisory Committee (SAC), MERA and the general public.

Directories:

MERA Members Matrix—available electronically.

Books:

Window to the Channel—provides a look at the varied resources that make the Channel Islands National Marine Sanctuary a national treasure and includes a conservation message.

Marine Mammals of the North Pacific Region—a waterproof guide.

Posters:

Channel Islands Aerial View poster—aerial photograph showing the four northern Channel Islands from the perspective of Anacapa Island looking west.

Sharks of the Channel poster—color poster showing the different kinds of sharks found within the Channel Islands National Marine Sanctuary.

Videos:

Introduction to the Channel Islands National Marine Sanctuary video

Charts:

NOAA Charts of the Channel Islands National Marine Sanctuary—currently available on-line at www.cinms.nos.noaa.gov

Discovery Cards:

Guide to Fishes of the Channel Islands—fish identification card.

K-12 Curricula:

Los Marineros Education Program curriculum—multidisciplinary approach to marine education for 5th graders. Available through the Santa Barbara Museum of Natural History.

Other Education/Outreach Materials:

Floating Key Chains—includes the CINMS web site address and is free to the public.

Channel Islands National Marine Sanctuary Tide Chart

Volunteer Opportunities:

Channel Islands National Marine Sanctuary interns—assist with research and educational outreach to support the Sanctuary goals and objectives.

Great American Fish Count (GAFC) survey—annual event where volunteer snorkelers and divers participate in fish survey dives and fill out scantron forms with the information about species observed and sighting frequency.

Outreach Event volunteers—these volunteers assist by providing information to the public about the sanctuary in annual events such as Harbor and Whale Festivals, and Earth Day.

Educational Opportunities

Informal Presentations—slide shows on different topics such as the natural history of the Channel Islands, resource protection and boater awareness, will soon be available for local organizations or civic clubs to check out or have a sanctuary representative present.

Sanctuary Cruises—During the summer months, the general public is invited to take a cruise out into the Channel Islands National Marine Sanctuary. Sanctuary staff and expert naturalists provide on-board presentations.

Web Links:

Cabrillo High School Aquarium—http://www.site.yahoo.com/cabrillo

California Department of Fish & Game—http://www.delta.dfg.ca.gov/index.html

Channel Islands National Park—http://www.nps.gov/chis

Island Packers—http://www.islandpackers.com

Los Marineros—http://www.sbnature.org/losmar/mariner.htm.txt

Love Lab—http://id-www.ucsb.edu/lovelab/home.html

Passage Productions—http://www.passagepro.com

RAIN Network—http://www.rain.org

Santa Barbara Museum of Natural History—http://www.sbnature.org

Santa Barbara Maritime Museum—http://www.sbmm.org

University of California, Santa Barbara Biodiversity Forum—http://real.geog.ucsb.edu/bioforum

Visitor Centers:

Outdoors Santa Barbara—a visitor center developed by the Channel Islands National Park, Channel Islands National Marine Sanctuary and U.S. Forest Service.

Sea Center—a visitor center of the Santa Barbara Museum of Natural History that contains exhibits on the Channel Islands National Marine Sanctuary.

Youth Activities Center—Channel Islands National Marine Sanctuary information and some exhibits available at the Channel Islands Harbor.

Santa Barbara Maritime Museum—shipwreck cultural resources exhibits.

Cabrillo High School Aquarium—Channel Islands National Marine Sanctuary exhibits are part of this high school aquarium.

Weather Kiosk—a touch screen located in the Santa Barbara harbor with web links to NOAA weather buoys and other pertinent information for boaters, fisherman, etc.

Cordell Bank National Marine Sanctuary

Fort Mason Building #201
San Francisco, CA 94123
415.561.6622
415.561.6616 fax
http:// www.sanctuaries.nos.noaa.gov/oms/omscordell/omscordell.html

Brochures & Flyers:

Cordell Bank National Marine Sanctuary fact sheet—an educational fact sheet that describes the unique features of Cordell Bank.

Newsletter and Newspapers:

Hydrosphere—bi-annual newsletter about the Gulf of Farallones and the Cordell Bank National Marine Sanctuaries. It includes articles about current research in the sanctuaries, educational offerings, volunteer programs, natural and cultural history of the sanctuaries, and field adventures.

Directories:

Marine and Coastal Educational Resources Directory—this directory lists marine and coastal educational organizations and agencies in the San Francisco and Monterey Bay areas. ($3.95)

Posters

Harvestable Bounty of the Sea poster—past and present fishing boats used in the Gulf of Farallones and Cordell Bank National Marine Sanctuaries. ($9.95)

Discovery Cards:

Discovery Card Sets—12 card sets with color photos, amazing facts, illustrations, and challenging animal quizzes. Available in the following subjects: marine mammals, gray whales, dolphins, humpbacks, and killer whales. ($3.99)

Resource and Educational Packets:

Marine Education Resource Library for Teachers—this information contains a wealth of materials perfect for bringing the ocean into the classroom. Some resources available include: curriculum guides, children's books, reference books, and videos.

Visitor Center:

Gulf of Farallones National Marine Sanctuary Visitor Center—the visitor center includes exhibits on Gulf of the Farralones and Cordell Bank and is an ideal field trip.

Fagatele Bay National Marine Sanctuary

P.O. Box 4318
Pago Pago, American Samoa 96799
684.633.7354
684.633.7355 fax
http://www.nos.noaa.gov/nmsp/FBNMS

Brochures & Flyers:

Fagatele Bay National Marine Sanctuary general brochure
Our Fragile Coral Reef brochure (available English & Samoan)
Research and Monitoring brochure
Watching Samoa's Humpback Whales brochure

Books:

Pacific Coral Reef coloring book—targeted for middle school students (grades 6th-8th).

K-12 Curricula

Marine Science Summer Camp curriculum (high school level)—series of lesson plans with various activities, etc., used primarily through the summer.

Other Education/Outreach Materials:

Postcards of the Fagatele Bay National Marine Sanctuary
Tide Booklet

Volunteer Opportunities:

AmeriCorp volunteers—volunteer for two years on sanctuary related projects
Village volunteers—outreach programs in the villages
Environmental Organization group—coordinated by the sanctuary

Educational Opportunities:

EnviroDiscoveries—coordinated effort by the Environmental Education Group—fun, outdoor nature experience where children camp out for one week and get an introduction to research, field work, swimming lessons, etc. Offered during the school year and summer months.
Village Outreach and Le Tausag (the call of the birds)—coordinated effort by the Environmental Education Group (Le Tausagi), that conducts plays, videos and lectures as outreach events.
School Outreach—sanctuary staff, educators, volunteers, etc. work with teachers and students to give presentations at local schools, coordinated effort with Le Tausagi.

Web Links:

American Samoa Coastal Zone Management—
http://wave.nos.noaa.gov/ocrm/czm/czmamericansamoa.html

Florida Keys National Marine Sanctuary

P.O. Box 500368
Marathon, FL 33050
305.743.2437
305.743.2357 fax
http://www.fknms.nos.noaa.gov

Brochures & Flyers:

Florida Keys National Marine Sanctuary general brochure
Lower Florida Keys Region general brochure
Upper Florida Keys Region general brochure—new four color brochure designed primarily for boaters showing location of zone and mooring buoys , how to navigate, etc.
Sea Grass placard—information on sea grass and how to navigate.
Do Not Touch Corals! placard—laminated for dive shops and for display on dive boats, available in English, Spanish & German.
Monroe County Recreational Lobster brochure—describes rules and regulations for recreational lobster fishing, targeted for sport/recreational divers.
Yellow Buoy Information card—explains that yellow buoys enclose special protected areas (zoned) within the Sanctuary, describes what activities are permissible and what activities are not permissible in these areas.
Summary of What You Need to Know to Help Protect Sanctuary Resources brochure—contains sanctuary regulations.
Florida Keys National Marine Sanctuary, Past-Present-Future brochure—describes geological and natural history of the Keys, habitat descriptions, and contains a map of the Keys with ocean currents.
Keeping Your Bottom Off the Bottom brochure—boat grounding prevention brochure.
Rental Boat Employee Checklist—laminated checklist to go through with a customer when they are renting a boat.
Shipwreck Trail brochure—describes the shipwreck trail for divers (9 wrecks in all).

Newsletters & Newspapers:

Sounding Line Newsletter

Directories:

Florida Keys Environmental Education Resource Directory—1997 edition—a guide to organizations that offer information and resources on environmental education in the Florida Keys region.

Books:

Florida Keys Environmental Story—a series of articles written by experts describing the natural and cultural history of the Florida Keys. A teacher's activity guide is also available.

Posters:

Florida's Coral Reef Ecosystem

Reef Fishes of the Florida Keys National Marine Sanctuary

Videos:

Protecting Paradise-Florida Keys Safe Boating Tips—used by Coast Guard Auxiliary in boating classes and by high schools educators to teach navigation skills to students.

Boat Groundings-Much More than an Inconvenience—video for the general public.

Introduction to Florida Keys National Marine Sanctuary

Reef Cleaning Procedures—available local dive clubs and shops that conduct underwater clean-ups on reefs.

Charts:

Teall's Guide, Key Largo to Conch Key—foldout guide contains information about FKNMS and is based on NOAA charts of local waters.

Guide, Marathon to Key West—foldout guide contains information about FKNMS and is based on NOAA charts of local waters.

Stickers:

Florida Keys Safe Boating Tips decal—useful for boaters and ocean goers.

Discovery Cards:

Shipwreck Trails—describes for divers the 9 individual wrecks on the shipwreck trail, map and illustrations on one side and information about archaeological, historical and marine biology on the other side.

K-12 Curricula:

Build an Ocean—classroom activity in which elementary school students build a coral reef ecosystem using a blue backboard and cutout figures.

Resource & Educational Packets:

Presentations to groups and organizations by staff on a variety of topics related to FKNMS and the Florida Keys coral reef system.

Sea grass Tool Box—designed to provide facts and photographs about the importance of sea grass as a resource and the extensive damage done by boat hulls and propellers, available for teachers, businesses, organizations, and media.

Coral Reef Classroom (CRC)—program includes classroom visit and half-day boat trip to snorkel on the coral reefs. Available for Monroe County middle and high school students. Participants learn to use water quality sampling equipment such as secchi disk, niskin bottle, refractometer, plankton tow net, and learn to snorkel.

Community Connection—eighth graders spend a day with the Florida Keys National Marine Sanctuary staff learning about resource protection, safe boating, and performing small job related tasks (2 students from Key Largo School per month in Spring).

Coral Shores High School Mentor Program and the Marathon High School Mentor Program—FKNMS staff serve as mentors for high school students investigating possible career choices. (November to May—Upper Keys-Spring only).

Teacher Grants (for Monroe County schools)—the Monroe County Environmental Education Advisory Council awards money provided by FKNMS for Monroe County school teachers to conduct "innovative environmental education" programs, related to the FKNMS.

Maritime Community Meetings—public meetings held periodically to update commercial and recreational users of the Sanctuary about current management issues, law enforcement concerns, research results and educational products and programs.

Other Education/Outreach Materials:

Education Permits—education permits are issued for a variety of education based activities. Examples: underwater filming, collecting for aquaria, student science projects, sampling during field education programs, picking up restricted species during field courses.

Waterways—ongoing weekly television series that features presentations about natural resources, scientific research, restoration activities pertaining to the Sanctuary.

Radio PSAs (Public Service Announcements)—marine environmental issues are presently addressed through 30-second "important messages" written and narrated by local middle school students and staff.

Volunteer Opportunities:

Great American Fish Count (GAFC) survey—annual event where volunteer snorkelers and divers participate in fish survey dives and fill out scantron forms with the information about species observed and sighting frequency.

Adopt-a-Reef—nine local dive shops participate from Key Largo to Key West to conduct underwater clean-ups of the Reef.

Team OCEAN—trained volunteer teams using the Sanctuary vessels are stationed at heavily visited reef sites during peak recreational boating seasons to educate and inform the public about the Florida Keys National Marine Sanctuary program, proper use of Sanctuary resources, and basic safety precautions.

Coral Reef Classroom assistants

Florida Keys National Marine Sanctuary intern program—check the FKNMS web site for more information.

Florida Keys NMS volunteer program—administrative assistant and volunteers help with the submerged resource inventory.

ReefMedic—volunteers will be trained on how to repair the reef and monitor damaged areas caused by small boat grounding incidents.

Visitor Centers:

John Pennekamp State Park—exhibit wall about the Florida Keys NMS.

Flower Garden Banks National Marine Sanctuary

216 West 26th Street, Suite 104
Bryan, TX 77803
409.779.2705
409.779.2334 fax
http:// www.sanctuaries.nos.noaa.gov/oms/omsflower/omsflower.html

Brochures & Flyers:

Flower Garden Banks National Marine Sanctuary general brochure
Flower Garden Banks National Marine Sanctuary Mooring Buoy Coordinates flyer
Flower Garden Banks National Marine Sanctuary Boundary Coordinates flyer
Availability of Information on the Flower Garden Banks National Marine Sanctuary
List of Commercial Charter Vessel Operators in the Flower Garden Banks National Marine Sanctuary
The Flower Gardens: A Chronology of Research
Volunteer Opportunities of the Flower Garden Banks National Marine Sanctuary
Sea Turtles of the Atlantic and Gulf Coasts of the United States—a black and white illustration and text that lists a couple of distinguishing features of each species of turtle.

Books:

"*Mass Spawning by Reef Corals in the Gulf of Mexico and Caribbean Sea: A Report on Project Reef Spawn '94*" Gulf of Mexico Science—special Flower Garden Banks NMS issue.

Posters:

Reef Fishes of the Flower Garden Banks and Stetson Bank

Videos:

Flower Garden Banks National Marine Sanctuary video (11.5 minutes), coupled with "Our Favorite Home Video" un-narrated (7 minutes), targets upper high school to adults.
Reef Romance video ($5.00)
Gardens Under the Sea video—48 minute award-winning documentary, targets upper high school to adult. ($19.95)

Maps:

Flower Gardens Multi-Beam Image Atlas

Charts:

Flower Gardens Chart MS-1—a NOAA bathymetric (non-navigational) chart with mooring buoy locations and Sanctuary facts.

Other Education/Outreach Materials:

Flower Gardens Kids Page—Coral: Plant, Animal, or Mineral?
Flower Gardens Kids Page—Manta Rays!
Relative Density Experiment—Observing the Effect of Salt on the Density of Water.
Coral Feeding Simulation—group activity that is appropriate for 4th grade through high school.
Traveling Trunk—Several resource trunks are available (with coral skeletons, videos, activity sheets, etc.) for loan to educators.

Volunteer Opportunities:

Outreach Event and Presentation Volunteers—annual FGBNMS presentations to Houston 7th graders at the Houston Museum of Natural Science, as well as staff the FGBNMS exhibit at outreach events.

Educational Opportunities:

Annual Education Workshop and Field Excursion to the FGBNMS
Classroom presentations
Training sessions—available for volunteers who give Flower Garden Banks NMS presentations.

Web Links:

Cyberways & Waterways—
http://www.tpwd.state.tx.us/expltx/eft/waterways/webcast.htm

Visitor Centers:

Texas State Aquarium—exhibitry on the Flower Garden Banks.
San Luis Pass County Park—small video "lounge" where the Flower Garden Banks NMS video is among those shown in the collection.

Gray's Reef National Marine Sanctuary

10 Ocean Science Circle
Savannah, GA 31411
912.598.2345
912.598.2367 fax
http://www.graysreef.nos.noaa.gov

Brochures & Flyers:

Gray's Reef National Marine Sanctuary general brochure—discusses regulations of the sanctuary as well as providing details about many of the species which live, breed and migrate through the area, such as right whales and loggerhead sea turtles.

Newspapers & Newsletters:

Shades of Gray—(electronic and hard copy available)

Books:

Coastal Waters Handbook—guide to encourage the entire family to step out and enjoy the natural communities of Georgia.
An Illustrated Field Guide to the Fishes of Gray's Reef National Marine Sanctuary

Posters:

Rivers to Reefs poster
Invertebrates of the Reef poster
Northern Right Whales poster

Videos:

From Whaling to Watching—educational module (handbook, video and two-part poster).
Gray's Reef NMS video—produced by headquarters about the Gray's Reef National Marine Sanctuary.

Maps:

Fishing Chart

K-12 Curricula

The Northern Right Whale from Whaling to Watching curriculum
Out Back, Up Close—to help younger children explore and discover things in their own backyard.
Endangered Connections—educational module for grades 6-8 (two manuals and a two part poster).
Fresh and Flowing Water—educational module for grades 1-5 (two manuals and 6 posters).
Gray's Reef National Marine Sanctuary: An Educational Handbook—middle school level handbook.

Other Education/Outreach Materials:

Refrigerator Magnets

Volunteer Opportunities:

Administrative Tasks volunteer
Volunteers for Scoping Meetings
Ocean Fest volunteers
High School and College interns

Educational Opportunities:

Holy Sea Cow Batman, It's a Manatee presentation
Color of Gray's Reef general presentation
Thar she Blows, the Right Whale presentation
Rotary Club and Civic Groups, Fishing and User Groups (~3 x month)
Student Ocean Council—designed to introduce students to ocean science related fields or careers, at no cost to students or teachers, junior and senior level.

Visitor Centers:

University of Georgia Marine Extension Service Aquarium—hosts Gray's Reef NMS exhibits.
Tybee Marine Science Center—hosts Gray's Reef NMS exhibits.

Gulf of Farallones National Marine Sanctuary

Fort Mason Building #201
San Francisco, CA 94123
415.561.6622
415.561.6616 fax
http://www.nos.noaa.gov/nmsp/gfnms/welcome.html

Brochures & Flyers:

Gulf of Farallones National Marine Sanctuary general brochure—a full color map with information about the Sanctuary.
Education Resource Library brochure
Pinnipeds of the Gulf of the Farallones NMS
Intertidal Habitat of the Gulf of the Farallones NMS
GFNMS, CBNMS, and MBNMS: Sanctuaries of the central California Coast

Newsletters & Newspapers:

Hydrosphere—bi-annual newsletter about the Gulf of Farallones and the Cordell Bank National Marine Sanctuaries. It includes articles about current research in the sanctuaries, educational offerings, volunteer programs, natural and cultural history of the sanctuaries, and field adventures.
NOAA's Bark—bi-annual volunteer newsletter

Directories:

Marine and Coastal Educational Resources Directory—this directory lists marine and coastal educational organizations and agencies in the San Francisco and Monterey Bay areas. ($3.95)

Posters:

Marine Mammals of the Gulf of Farallones poster—a map of the Gulf of Farallones National Marine Sanctuary with illustrations of 23 marine mammals that call the Sanctuary home. ($9.95)
Los Pajaros de Los Esteros poster—"Birds of the Estuaries" is a watercolor of the birds that frequent the Gulf of Farallones National Marine Sanctuary. ($9.95)
Gulf of the Farallones National Marine Sanctuary Mural poster—a mural of the underwater open ocean habitat around the Farallon Islands.

Discovery Cards:

Discovery Card Sets—12 card sets with color photos, amazing facts, illustrations, and challenging animal quizzes. Available in the following subjects: marine mammals, gray whales, dolphins, humpbacks, and killer whales. ($3.99)

Resources and Educational Packets:

Marine Education Resource Library for Teachers—this library contains a wealth of materials perfect for bringing the ocean into the classroom.
Rocky Intertidal Teachers and Educators Packet—the Farallon Marine Sanctuary Association (FMSA) is developing a series of sanctuary habitat packets for use in educational settings. Two versions of the packet are available—elementary or secondary school level.($5.00)
General Information Packet on the Gulf of the Farallones—available and free to the public.

Slide Shows—presentations on GFNMS species and habitats available to teachers and the general public.

K-12 Curricula:

Project Ocean—an exciting education program that turns K-6 grade classrooms into marine ecosystems.

Volunteer Opportunities:

SEALS, A Seal Interpretation and Monitoring Program—this program trains volunteers to monitor harbor seal behavior and educate the public about responsible behavior around wildlife.

Beach Watch—trains citizen-scientists to survey and document the resources of the sanctuaries.

Visitor Center—volunteers receive training on the Gulf of Farallones and educate the public about the sanctuary and its resources.

Internship Program—undergraduate and graduate students assist researchers and staff to facilitate the goals of the sanctuary.

Educational Opportunities:

Adopt-A-Beach—25 San Francisco schools participate in this program at the Golden Gate National Recreation Area; students learn first about the beach and its communities and then join a coastal clean-up.

School Programs—at the Presidio visitor center.

Teacher-at-Sea program—Gulf of the Farallones NMS offers the Teacher-at-Sea program that allows local teachers to participate in research cruises and the *Sustainable Seas Expeditions.*

Lecture Series—one every other month (6/year).

Field Adventures—a naturalist takes out public members.

Web Links:

Farallones Marine Sanctuary Association (FMSA)—
http://www.farallones.org

Visitor Centers:

Gulf of Farallones National Marine Sanctuary Visitor Center—the visitor center includes exhibits on Cordell Bank and Gulf of the Farralones National Marine Sanctuaries and is an ideal field trip. It is filled with fascinating facts and fun activities about the sanctuaries. At the visitor center, you can interact with animals in the sanctuaries at a touch tank, glimpse under the sea at the sanctuaries through the aquarium, see a real white shark jaw, touch the fur of sea otters and seals, discover animals underneath the microscope, and imagine giant whales filtering tiny shrimp-like krill through baleen.

Pacifica Visitor Center—this visitor center highlights recreational activities in the Sanctuary and is a great place to see an adult male sea lion skeleton.

Hawaiian Islands Humpback Whale National Marine Sanctuary

726 South Kihei Road
Kihei, HI 96753
808.879.2818
808.874.3815 fax
http://www.hihwnms.nos.noaa.gov

Brochures & Flyers:

Welcome to the Hawaiian Islands Humpback Whale National Marine Sanctuary general brochure—official map and brochure of the Hawaiian Islands Humpback Whale National Marine Sanctuary, regulations, boundaries, and projects.

Ko'ie'ie Fishpond—one page brochure on the ancient Hawaiian fishpond located in front of the Maui Sanctuary office.

Volunteering for the Humpback Whale National Marine Sanctuary—one page flyer on the volunteer programs at the Maui office.

Humpback Whale Approach Regulations—waterproof, pocket size card with federal approach regulations.

Pehea 'Oe E Hiki Ke Ho'omalu I Ka Moana (What you can do to protect the ocean)—one page flyer on guidelines that you can follow to help protect our ocean environment. (available in English & Hawaiian)

Top Ten Questions Regarding the Hawaii Sanctuary—popular one page brochure addressing the most frequently asked questions concerning the Hawaii Sanctuary.

What has the Hawaii Sanctuary Done for Hawaii? brochure—discusses the various projects that the Hawaii Sanctuary has initiated or co-sponsored in Hawaii.

Na Meakanu o Hawai'i Nei (The Plants of Hawaii)—identification booklet of the terrestrial plant species that exist at the Maui Sanctuary office; created by a volunteer and a student intern.

The Cultural Importance of Whales in Hawai'i brochure—used to promote and educate the community about the Hawaiian culture and the connection between the culture and whales.

Hawaii Marine Mammal & Sea Turtle Viewing Guidelines brochure—guidelines for safe wildlife watching.

2000 Sanctuary Happenings brochure—printed quarterly.

Books:

Sea Turtle coloring book—an introduction to Hawaii's sea turtles and conservation techniques (available in English & Hawaiian).

Pacific Coral Reef coloring book—tri-lingual coloring book (Hawaiian, Samoan, and English) on the importance and conservation of the coral reef.

Kohola and Kolea Children's Story coloring book—based on a story from the Marshall islands concerning the plover and the humpback whale (available in English & Hawaiian).

Ocean User's Guidebook—user manual of the various federal regulations pertaining the marine mammals and turtles in Hawaii.

Posters:

The Kohola (Humpback Whale) poster

Stickers:

I Love Whales: Hawaiian Islands Humpback Whale National Marine Sanctuary sticker

Discovery Cards:

Species Cards—four of the federally protected species found in Hawaii—the humpback whale, sea turtle, dolphin and monk seal are each depicted on a one page sheet.

Enforcement Cards

Resources and Educational Packets:

Teacher Kits—teacher packets, whale models, and videotapes available upon request.

Activity Sheets—Whale Migration, Whale Quiz , Whale Connect the Dots , Mammal Size Comparison, Humpback Whale Scramble, and Whale Behavior Identification.

Other Education/Outreach Materials:

Ocean Buttons/Ocean Magnets—children design and color ocean buttons and magnets.

Whale Puzzle—six-foot puzzle is a favorite activity for children.

Whale of Fortune game—popular interactive game, children and adults spin a wheel and then answer questions concerning whale behavior, biology and fun facts.

Whale Tail—life size whale tail used to demonstrate the size of humpback whales.

Scavenger Hunt—designed to supplement displays in the Education Center and requires students to search for answers to questions about specific displays and general Sanctuary information, i.e. sanctuary boundaries, turtles, whales, etc.

Whale Migration Maze—a walk-through display of humpback whale's migration from Alaska to Hawai'i (approx. size is 40ft x 40ft).

Volunteer Opportunities:

Education Center (Maui Headquarters) volunteers—help run the education center, including tours of the center, library work, and development of new education materials.

Annual Public Events volunteers—help at outreach events.

On site (Maui Headquarters)volunteers—help with office work, gardening, building facilities and special events.

Educational Opportunities:

Ocean User's Enforcement Workshop—annual workshop to promote better understanding of Federal protected species regulations and watchable wildlife ethics.

Volunteer Orientation—half-day orientation.

Windjammer Cruises—complimentary whale watch cruises for Maui school children.

Monthly Lecture Series (Maui)—held the second Tuesday of the month, this free lecture series provides an opportunity for Maui residents and visitors to learn more about Hawai'i marine environment.

Annual Lecture Series (Kaua'i)—held in conjunction with annual family ocean fair at Kilauea Point.

School Visits—sanctuary staff journeys to classrooms to conduct educational activities on humpback whales, the sanctuary and the *Sustainable Seas Expeditions*.

Site Visits at Maui Education Center—a variety of educational hands-on activities are used to teach students of all ages about the sanctuary, whales, Ko'ie'ie Fishpond, limu (seaweed), turtle, native Hawaiian coastal plants and the adjacent sand dune ecosystem.

Sanctuary Ocean Counts—annual count of whales and other marine mammals from shore-based locations around the islands.

Kauai's Children's Discovery Museum—annual sponsorship of ocean/Sanctuary-related exhibitry.

Careers on the Waters (O'ahu)—annual ocean career awareness day on board the *Navatek*.

Web Links:

Hawai'i Whale Research Foundation—http://www.hwrf.org

Marine Option Program—http://www2.hawaii.edu/mop

Ohi'a Productions—http://www.ohia.com

Whale Watching Web site—http://www.physics.helsinki.fi/whale

Visitor Centers:

Hawaiian Islands Humpback Whale National Marine Sanctuary Visitor Center—located in Kihei at the Maui Headquarters.

Sea Life Park (Oahu)—existing display of National Marine Sanctuary Program.

Maui Ocean Center (Maui)—display on the HIHWNMS.

Kaua'i Sanctuary Office—indoor display for planned and new sanctuary office in Lihue.

Monitor National Marine Sanctuary

c/o The Mariners' Museum
100 Museum Drive
Newport News, VA 23606
757.599.3122
757.591.7310 fax
http://www.nos.noaa.gov/nmsp/monitor

Brochures & Flyers:

Monitor National Marine Sanctuary general brochure

Comprehensive bibliography—a bibliography of Monitor-related material, with periodic supplements.

The Ten Most-Often Asked Questions About the Monitor National Marine Sanctuary

Plans of the Monitor—blueprints of scale drawings of the ship and the turret can be provided upon request.

Biography of John Erickson

Why the Monitor is Designated a Sanctuary flyer

Significant Dates in the History of the Monitor flyer

Current State of the U.S.S. Monitor Shipwreck flyer

Newsletters & Newspapers:

Cheesebox newsletter—periodic activity report is written for a general audience and contains current information on Monitor-related activities including on-site research, exhibits, management issues, and historical notes.

Books:

Expedition to the Monitor National Marine Sanctuary: Data Analysis and Final Report—written by Barto Arnold, et. al.

The Crewmen of the USS Monitor: A Biographical Directory—written by Irwin Berent.

Preliminary Report: Stereo Photography and Artifact Retrieval 16 July—2 August 1977 Monitor Marine Sanctuary—written by Floyd Childress, et. al.

Research and Education Combine to Bring the Monitor's Story Ashore—written by Dina Hill.

The Monitor—Lost and Found—written by Justin Kenney.

The Monitor National Marine Sanctuary: Preserving the Past for the Future

Ironclad Captains: The Commanding Officers of the USS Monitor—written by William Still.

Monitor Builders: A Historical Study of the Principal Firms and Individuals Involved in the Construction of the USS Monitor

Preliminary Report: Archaeological and Engineering Expedition Monitor Marine Sanctuary August 1-26, 1979—written by Gordon Watts, et. al.

A Look at the Monitor National Marine Sanctuary: Past, Present, and Future booklet—55 pages with reference section.

Posters:

Monitor National Marine Sanctuary poster—dramatic underwater photograph showing a diver at the stern on the Monitor.

Videos:

Down to the Monitor—film produced in 1980; it contains an excellent historical overview and footage of archaeologists working at the wreck. (20 min.)

Back to the Monitor—narrated video on research and education in the Monitor National Marine Sanctuary. It includes a historical overview of the ship and color footage of the wreck of the Monitor and the marine life that inhabit it.

Maps:

Location of the Monitor National Marine Sanctuary map

K-12 Curricula:

Monitor National Marine Sanctuary curriculum—designed for 5th graders.

Printed curriculum—incorporated into an American History course, includes a list of activities, teacher's guidebook.

Resources and Educational Packets:

Outreach Kit—full of the MNMS materials, with posters and information from all the sanctuaries, reproduced artifacts from the Monitor; teacher' s guidelines and suggested activities.

Monitor National Marine Sanctuary model—color model is designed for children at the third-grade level and above; it is an easily assembled cardboard model with supplemental information about the Monitor and the Monitor National Marine Sanctuary.

Slides and Photographs—a number of images of the Monitor are available upon request.

Other Education/Outreach Materials:

Monitor Sanctuary bookmarks

Educational Opportunities:

Public Presentations—presentations for all types of groups.

Teacher Workshops—the Mariner's Museum regularly hosts teacher workshops.

Visitor Centers:

Mariner's Museum—serves as major visitor center for the MNMS

Hampton Roads Naval Museum in Norfolk, VA.

Monterey Bay National Marine Sanctuary

299 Foam Street, Suite A
Monterey, CA 93940
408.647.4201
408.647.4250 fax
http://www.mbnms.nos.noaa.gov

Brochures & Flyers:

Monterey Bay National Marine Sanctuary general brochure

Kayaking in the Monterey Bay National Marine Sanctuary brochure

Diving in the Monterey Bay National Marine Sanctuary brochure

Boating in the Monterey Bay National Marine Sanctuary brochure

Together We Can—geared towards kids and families.

Citizen's Guide to Clean Water and the Monterey Bay National Marine Sanctuary—an introduction to the sanctuary and the habitat and focuses on human impact, coastal links, watersheds, water quality issues, etc.

Monterey Bay Begins on Your Street—brochure on urban run-off targeted to the general public and families (English & Spanish).

Monterey Bay National Marine Sanctuary Regulations brochure

Water Quality Protection Program brochure—describes the water quality protection program.

Newsletters & Newspapers:

News from the Monterey Bay National Marine Sanctuary newsletter (1 issue/year)

Ecosystem Observations—an annual report about the Monterey Bay NMS.

Monterey Bay National Marine Sanctuary—Your Guide to its Natural History and Recreation newspaper

Directories:

Marine & Coastal Educational Resources Directory

Monterey Bay National Marine Sanctuary Citizen's Stewardship Guide—list of opportunities for a volunteer in the Monterey Bay area; available on-line.

List Serv—available for teachers and educators.

Research Directories—updated by Research Coordinator at MBNMS.

Books:

A Natural History of the Monterey Bay National Marine Sanctuary
Sanctuary Explorations

Posters:

Are you Feeding Our Wildlife?—water quality poster.
Grand Canyon of Monterey Bay poster ($12.95)
Storm Drains Lead Straight to the Ocean poster—water quality produced for the protection program.
Good Cleaning Practice poster—for the Auto Repair Industry.
Good Cleaning Practice poster—for the Food & Restaurant Industry.

Videos:

Visitor's Guide to the Monterey Bay National Marine Sanctuary (12 minutes)
Watersheds to Seashores (25 minutes)

Maps:

Bathymetric and Topographic Map—of the Monterey Bay National Marine Sanctuary ($19.95)

Charts:

Monterey Bay National Marine Sanctuary—nautical chart.

Stickers:

Kid's artwork sticker— "I love the ocean!" Monterey Bay National Marine Sanctuary.

Discovery Cards:

Fishwatching Dive Card—Channel Islands and Monterey Bay fishes.

K-12 Curricula:

Sanctuary Science—K-6 packets and 7-12 grade level
The Land—Sea Connection—teacher activities to accompany new map.

Resources and Educational Packets:

Monterey Bay National Marine Sanctuary general slideshow—20-25 minutes.

Other Education/Outreach Materials:

Recycled pencils—blue (recycled blue jeans) and green (recycled money) pencils with MBNMS web address listed.

Educational Groups:

Sanctuary Education Panel

Volunteer Opportunities:

Urban Watch volunteer program—monitor storm drains; approximately 15 volunteers/year.
Monterey Bay National Marine Sanctuary internships—the following internship opportunities are available to undergraduate or graduate college students. For an accurate list of what opportunities are available—http://www.mbnms.nos.noaa.gov/educate/ed_volun.html
BEACHCOMBER volunteers—a beach monitoring pilot study, utilizing volunteers to sample selected sections of beach for dead marine birds and mammals.
SOS's Sanctuary Stewards program—volunteer program dedicated to preserving the ecological integrity of California's central coast.
CMC's Baynet program—an innovative field docent program to enhance public awareness and understanding of the Monterey Bay National Marine Sanctuary, its wildlife, policies and programs.
Water Quality and Watershed Monitoring—volunteer opportunity in Santa Cruz through the Coastal Watershed Council.

Educational Opportunities:

Presentations—volunteers conduct presentations on behalf of the Monterey Bay NMS.
Teacher Workshops—annual event that focus on teaching educators how to conduct water quality or intertidal monitoring with students.
Model Urban Runoff Program (MURP)—work with different cities to get them to reduce urban run-off.
Informal training—available in kayak shops and displays set up in Monterey kayak and dive shops.
Sanctuary Education Panel—meets six times a year.
Sea Camp—a week-long ocean science education and conservation residential program, targeting 5th grade level.

Visitor Centers:

State Parks—MBNMS permanent exhibits at visitor centers & parks.
Monterey Bay Aquarium—some information on MBNMS throughout aquarium at various exhibits.
Friends of the Elephant Seal in Cambria—volunteer group with visitor center with MBNMS displays.
MBNMS Visitor Center—located at 299 Foam Street in Monterey, CA.
San Carlos Park—memorial to David Packard, exhibits on Monterey Bay NMS.

Olympic Coast National Marine Sanctuary

138 West First Street
Port Angeles, WA 98362
360.457.6622
360.457.8496 fax
http://www.ocnms.noaa.gov

Brochures & Flyers:

Olympic Coast National Marine Sanctuary general brochure
The Shipwreck, Austria—fact sheet

Newsletters & Newspapers:

Supplemental Articles for the Olympic National Park—approx. 4-page insert to the National Park publication.
Sanctuary Advisory Committee Annual Report

Videos:

Student Ocean Summit video (approximately 16 minutes)

Olympic Coast National Marine Sanctuary—discusses the values of the Sanctuary from a stakeholders' point of view.

Resources and Educational Packets:

Plankton Packet—activity sheet for ocean fairs, etc. targeted for elementary grade levels.

Volunteer Opportunities:

Olympic Coast National Marine Sanctuary intern

Olympic Coast National Marine Sanctuary volunteer

Earth Day 2000 beach clean-up event

COAST Project-Beach Bird Monitoring Project—directed by the University of Washington.

Educational Opportunities:

Olympic Park Institute (OPI) Field Seminars—sanctuary staff who are experts in their fields join with OPI staff to lead six extraordinary adventures to the wilderness shores, offshore rocks and rolling swells of the rugged Olympic Coast.

- *The Fabled Cape: Life and Legends of Cape Flattery*
- *Cape Alava: A Backpack into the Past*
- *Thinking Like an Ocean: Sea Kayaking the Olympic Coast*
- *Seabirds of the Olympic Coast: An Offshore Boat Excursion*
- *Washington Sea Otters: Natural History & Ecology*
- *Best of the Olympic Coast* backpack

Nature Walks—July through Labor Day there are daily nature walks.

Teacher field trips

Public Presentations—luncheon and multi-media presentation along with other staff doing presentations.

Lecture Programs and Nature Walks—available for elder hostels and the general public.

The West End Community Shipwreck Project—community based research project on Maritime history.

Visitor Centers:

Kalaloch Visitor Center

Stellwagen Bank National Marine Sanctuary

174 Edward Foster Rd.
Scituate, MA 02066
781.545.8026
781.545.8036 fax
http://alpha.nos.noaa.gov/oms/omsstellwagen/omsstellwagen.html

Brochures & Flyers:

Sanctuary flyer—underwater topography and basic information about the sanctuary.

Mapping the Sea Floor and Biological Habitats of the Stellwagen Bank National Marine Sanctuary flyer—produced by the U.S. Geological Survey about a multi-beam sea-floor-mapping project in the sanctuary.

Whalewatching Guidelines: Northeast Region including Stellwagen Bank National Marine Sanctuary—guidelines for safe boating around cetaceans, including regulations specific to right whales.

Newsletters & Newspapers:

Stellwagen Soundings—newsletter from the Sanctuary is produced approximately two times a year. The 8-page newspaper includes feature stories on Sanctuary species and news on the latest regulatory programs and conservation issues. Subscriptions are free to any interested parties; multiple copies can be sent to a single address.

Posters:

Stellwagen poster—a 20" x 30" full-color poster showing underwater topography of Stellwagen Bank, Massachusetts Bay and Cape Cod.

Videos:

Stellwagen Bank: An Investment for the Future—a 20-minute video that focuses on the sanctuary setting and mission.

From Whaling to Watching: the Northern Right Whale—a 30-minute video that complements the curriculum book of the same name.

Bounty of the Bank: A case study of the Stellwagen Bank Sanctuary—a 13-minute video that looks at the bank environments in the marine ecosystem, and Stellwagen Bank Sanctuary as a natural laboratory for the greater Gulf of Maine.

Maps:

Sea Floor Topography in the Stellwagen Bank National Marine Sanctuary—18 quadrangles; produced by the U.S. Geological Survey, 1997.

Stickers:

Large Whales: Alert to Boaters—provides information about safe boating around large whales and phone numbers to report dead or entangled whales or irresponsible vessel behavior.

K-12 Curricula:

From Whaling to Watching—this curriculum package consists of a 20-minute video and a 40-page book detailing the history, biology, and conservation programs for the endangered northern right whale (intended for upper elementary or middle school students).

Spirit of the Auk—this middle school curriculum focuses on human interactions with marine species (particularly whaling and fishing), sustainable use of resources, abundance, exploitation, extinction, food webs, and other issues.

The Food Bank CD-ROM—this CD-ROM looks at the marine food web at the Stellwagen Bank National Marine Sanctuary and contains hundreds of underwater photographs of marine species, dozens, of video clips, and games.

Volunteer Opportunities:

Student volunteers—the sanctuary hosts unpaid interns/volunteers during the summer months that help in public outreach and research capacities.

Docent Program—a docent program of trained volunteers who will be available to represent the sanctuary at public events and offer education programs to local schools.

Visitor Centers:

Sanctuary Exhibit—(April-October) at the Independence Mall, Kingston, MA. This display area features photographs of important sanctuary species and information about the sanctuary and its resources.

Thunder Bay National Marine Sanctuary

2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
734.741.2270
734.741.2176 fax
http://www.glerl.noaa.gov/glsr/thunderbay

Additional Educational Resources

Coral Reef Alliance—http://www.coral.org
International Year of the Reef—http://www.coral.org/IYOR
Reef Relief—http://www.reefkeeper.org

Educational Resources:

Association of Zoos and Aquariums—http://www.aza.org
Center for Marine Conservation—http://www.cmc-ocean.org
Classroom Connect—http://www.classroom.net
Earthwatch—http://www.earthwatch.org
EPA Oceans—http://www.epa.gov/owow
Estuarine Research—http://www.nos.noaa.gov/ocrm/nerr/nerrs_education.html
Environmental Defense Fund—http://www.edf.org
GOALS (Global Online Adventure Learning Site)—http://www.goals.com
Great American Fish Count—http://www.fishcount.org
Harbor Branch Oceanographic Institution—http://www.hboi.edu
Hawksbill Turtles—http://www.topia.com/hawksbill
Live from Antarctica 2—http://quest.arc.nasa.gov/antarctica2
Love Lab—http://id-www.ucsb.edu/lovelab/index.html
Marine Biology Web—http://life.bio.sunysb.edu/marinebio/mbweb.html
Marine Sanctuaries—http://www.sanctuaries.nos.noaa.gov
Marine Science Careers—http://www.marinecareers.net
Monterey Bay Aquarium—http://www.mbayaq.org
Monterey Bay Aquarium Research Institute—http://www.mbari.org
Mote Marine Laboratory—http://www.mote.org
Mystic Aquarium—http://www.mysticaquarium.org
NASA's Earth Science Enterprise—http://www.earth.nasa.gov
National Geographic Society—http://www.nationalgeographic.com
National Science Teacher's Associations—http://www.nsta.org
New Millennium Observatory—htttp://newport.pmel.noaa.gov/nemo_cruise98
NOAA's Classroom at Sea—http://classroomatsea.noaa.gov
NOAA Central Library Internet Locator—http://www.lib.noaa.gov/docs
NOAA Corps Fleet—www.nc.noaa.gov/fleet.html
NOAA Ocean—http://www.noaa.gov/ocean.html
NOAA Teacher at Sea Program—http://www.tas.noaa.gov
NPR Radio Expeditions—http://www.npr.org/programs/RE/
Ocean Futures—http://www.ocean.futures.org
Ocean Net—http://www.oceannet1.com
Ocean Sciences Teacher Education Resource—http://www.vims.edu/bridge
Save our Seas—http://planet-hawaii.com/sos
Sea Grant Marine Careers—http://www.marinecareers.net
The Nature Conservancy—http://www.tnc.org
Year of the Ocean—http://www.yoto98.noaa.gov

Fisheries:

Building Sustainable Fisheries—http://www.noaa.gov/nmfs/sustain.html
National Marine Fisheries Service Stats and Economics—http://www.st.nmfs.gov/st1/recreational/index.html
National Marine Fisheries—http://www.nmfs.noaa.gov

Hydrothermal Volcanoes:

Adventure Under the Oregon Coast—http://www.teleport.com/~samc/seas/deep1.html
NOAA Vents Program—http://www.pmel.noaa.gov/vents/geology/video.html
VENTS Program—http://www.pmel.noaa.gov/vents/home.html

Maps:

Digital Images or electronic charts—http://www.maptech.com
Environmental Protection Agency's Maps on Demand—http://www.epa.gov/enviro/html/mod/mod.html
NOAA Maps—http://mapfinder.nos.noaa.gov
NOAA Nautical Charts and Mapping—http://mapfinder.nos.noaa.gov
Ordering page for NOAA nautical charts—http://chartmaker.ncd.noaa.gov/staff/prices.htm

Marine Mammal Migration:

Journey North—http://www.learner.org/jnorth
Sea Turtle Tracking Program—http://www.cccturtle.org/sat1.htm
Turtle Migration Data—http://www.nos.noaa.gov/nmsp/grnms
Whale Net—http://whale.wheelock.edu
On the Trail of the Right Whale—www.rightwhale.noaa.gov

Oceans, Coasts, and Tides:

Adopt-A-Beach Program—http://www.glo.state.tx.us

Adopt the Coast Action Kit—
http://www.nos.noaa.gov/ocrm/pcd/outreach.html
National Data Buoy Center—http://www.ndbc.noaa.gov
Tide Predictions—http://tidesonline.nos.noaa.gov

Online Data:

Activities Using Research Data—http://www.oar.noaa.gov
Environmental Services Data Direct—http://www.esdim.noaa.gov
National Geophysical Data Center—
http://www.ngdc.noaa.gov/ngdc/ngdcsociety.html
National Weather Service—http://www.nws.noaa.gov
Project YOTO Drifters—http://www.drifters.doe.gov
Reef Environmental Education Foundation—http://www.reef.org

Online Expeditions:

JASON Project—http://www.jasonproject.org
Ocean Adventure—http://library.thinkquest.org/18828
Reefs of the Gulf—http://gulftour.tamu.edu/home.html
Franck Goddio Society—http://www.underwaterdiscovery.org
University of Washington "REVEL Project"—
http://www.ocean.washington.edu/outreach/revel

Satellite Imagery:

Satellite imagery—http://terraserver.microsoft.com
SeaWiFS Project—http://seawifs.gsfc.nasa.gov
Topex Poseidon—http://www.jpl.nasa.gov

SCUBA Diving:

Divers Alert Network (DAN)—http://www.diversalertnetwork.org
Great American Fish Count—http://www.fishcount.org
NOAA Diving—http://www.dive.noaa.gov
Scuba Central—http://www.scubacentral.com

Shipwrecks and Archaeology:

Links to Technical Diving—http://www.scubacentral.com
Links to Underwater Archaeological Resources—
http://fiat.gslis.utexas.edu:80
Nautical Archaeology Program, Texas A & M University—
http://nautarch.tamu.edu
Submerged Cultural Resources, National Park Service—
http://www.nps.gov/scru/home.htm

Submersibles:

Alvin—http://www.marine.whoi.edu/ships/alvin/alvin.htm
Designing a Submersible—http://www.32ndparallel.com/custom.htm
Extreme 2000—Voyage to the Deep—
http://www.ocean.udel.edu/deepsea/
National Undersea Research Program—
http://www.ucc.uconn.edu/~wwwnurc/nurp.html
Nuytco Research Ltd.—http://www.nuytco.com
ROV Tiburon—http://www.mbari.org/rd/tiburon/index.html
Submersibles—http://www.rcboats.com
Submersibles Bathyscaph Scale Models Alvin Trieste—
http://www.globaloutlet.com
Woods Hole Oceanographic Institute's ROVs—
http://www.marine.whoi.edu/ships/rovs/rovs.htm
Woods Hole Oceanographic Institute's Future Directions—
http://www.marine.whoi.edu/ships/future_directions.htm

Teacher Resources:

Earth and Sea Investigations—http://www.earthsea.org
Hotlinks page—http://members.aol.com/rmt1838/hotlinks.html
Ocean Research Group—http://www.oceanicresearch.org
Resources for Teachers—http://www.csun.edu/~vceed009
Sea Grant Teacher Resources—
http://www.mdsg.umd.edu/NSGO/whatisseagrant.html#education
Sea Grant News Media Center—http://www.seagrantnews.org
The Difference between Weather and Climate—
http://www.ogp.noaa.gov/library/library.htm
Weather Education—
http://www.nws.noaa.gov/er/btv/html/wxeduc.html
Whale Sounds—http://www.cetaceanresearch.com

Weather:

El Niño and Climate Prediction—
http://www.pmel.noaa.gov/toga-tao/el-nino
El Niño Homepage—http://www.ogp.noaa.gov/enso
National Hurricane Center—
http://www.hurricanehunters.com/welcome.htm
NOAA Ship on El Niño Watch—
http://pmel.noaa.gov/tao/kaimi/index.shtml
NOAA Weather Radio—http://www.nws.noaa.gov/nwr/nwrbro.htm
Sea Education Association—http://www.seaeducation.org
Weather Education—http://www.nws.noaa.gov/om/educ/educ2.htm
Weather Education—http://www.nws.noaa.gov/om/edures.htm
Weather Education Information in the Regions—
http://www.nws.noaa.gov/regions.shtml

Books and Articles:

Anonymous. 1994. *Fish. The Tragedy of the Oceans.* The Economist 330 (7855): 13-14; 21-24.
Bardach, John. 1968 *Harvest of the Sea.* New York: Harper & Row, 301pp.
Bascom, Willard. 1928. *The Crest of the Wave. Adventures in Oceanography.* New York: Harper & Row.
Beebe, William. 1934. *Half Mile Down.* New York: Harcourt, Brace and Co.
Broad, William J. 1997 *The Universe Below: Discovering the Secrets of the Deep-Sea.* New York: Simon and Schuster.
Carson, Rachel. 1951 *The Sea Around Us.* New York: Oxford Press.
Chadwick, Douglas H. 1998. *Blue Refuges: U.S. National Marine Sanctuuries.* National Geographic 193 (3): 2-31.
Cousteau, Jacques. 1953. *The Silent World.* New York: Harper & Brothers.
Cuyvers, Luc. 1993. *Sea Power: A Global Journey.* Annapolis: Naval Institute Press.
Daily, Gretchen C., and Paul R. Ehrlich. 1992. *Population, Sustainability, and Earth's Carrying Capacity.* Bioscience 42 (10): 761-771.

Earle, Sylvia A. 1995. *Sea Change: A Message of the Oceans*. New York: Random House, Inc.

Earle, Sylvia A., and Al Giddings. 1980. *Exploring the Deep Frontier: The Adventure of Man in the Sea*. National Geographic Society.

Earle, Sylvia A. 1999. *Hello Fish*. Washington, DC.: National Geographic Society.

Earle, Sylvia A. 1999. *Dive*. Washington, DC.: National Geographic Society.

__________. 1979. *Humpbacks: The Gentle Giants*. National Geographic 155 (1): 2-17.

__________. 1990. *Ocean Everest—An Idea Whose Time Has Come*. Marine Technology Society Journal 24 (2): 9-12.

__________. 1989. *Sharks, Squids, and Horseshoe Crabs: The Significance of Marine Biodiversity*. Bioscience 41 (7): 506-509.

__________. 1987. *Plastics in the Ocean: More Than a Litter Problem*. Washington, D.C.: Center for Marine Conservation.

Eckert, Scott. 1992. *Bound for Deep Water*. Natural History March: 28-35.

Ellsberg, Edward. 1929. *On the Bottom*. New York: Dodd, Mead.

Gore, Al. 1990. *Earth in the Balance: Ecology and the Human Spirit*. New York: Houghton Mifflin.

Gore, Rick. 1990. *Between Monterey Tides*. National Geographic 177 (2): 2-43.

Grassle, J. Frederick. 1991. *Deep-Sea Benthic Biodiversity*. Bioscience 41 (7): 464-469.

Hanson, Lynne Carter, and Sylvia A. Earle. *"Submersibles for Science."* Oceanus 30 (3): 31-38.

Hass, Hans. 1951. *Diving to Adventure*. Garden City, New York: Doubleday & Co., Inc.

Hass, Lotte. 1972. *Girl on the Ocean Floor*. London: Harrap.

Herring, Peter J., A.K. Cambell, M. Whitefield, and L. Maddock. 1989. *Light and Life in the Sea*. Cambridge, U.K.: Cambridge U. Press.

Jannasch, Holger. 1990. *Marine Microbiology: A Need for Deep-Sea Diving?* Marine Technology Society Journal 24 (2): 38-41.

Kahari, Victoria A. 1990. *Water Baby: The Story of Alvin*. New York: Oxford U. Press.

Link, Marion. 1973. *Windows in the Sea*. Washington, D.C.: Smithsonian Institution Press.

Lovelock, James E. 1979. Gaia. *A New Look at Life on Earth*. New York: Oxford U. Press.

McKinnon, Micahel, and Peter Vine. 1991. *Tides of War*. London: Boxtree Ltd.

Nash, Ogden. 1937. *A Beginner's Guide to the Oceans* in Good Intentions. Boston: Little Brown and Company.

Our Living Oceans: *The First Annual Report on the Status of U.S. Living Marine Resources*. Washington, D.C.: U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

National Science Teachers Association. 1994. *Project Earth Science:* Physical Oceanography Curriculum. Grades 5-10, 244 pp.

National Science Teachers Association. 1992. *Earth: The Water Planet Curriculum*. Grades 6-10, 204 pp.

National Science Teachers Association. 1993. *Earth at Hand Curriculum*. Grades 5-10, 176 pp.

National Science Teachers Association. 1997. *Decisions-Based on Science Curriculum*. Grades 9-10, 144 pp.

Piccard, J., and R. Dietz. 1961 *Seven Miles Down*. New York: G.P. Putnam's Sons.

Prager, Ellen. 2000 *The Oceans*. New York: McGraw-Hill.

Robison, B. 1990. *Biological Research Needs for Submersible Access to the Greatest Ocean Depths*. Marine Technology 24 (2): 34-37.

Thorne-Miller, Boyce. 1993. *Ocean*. San Francisco,: Collins Publishers.

Thorne-Miller, Boyce, and John Catena. 1991. *The Living Ocean*. Washington, D.C.: Island Press.

Walford, Lionel A. 1958. *Living Resources of the Sea: Opportunities for Research and Expansion*. A Conservation Foundation Study. New York: Ronald Press.

Walsh, Don. 1990. *Thirty Thousand Feet and Thirty Years Later: Some Thoughts on the Deepest Ocean Presence Concept*. Marine Technology Society Journal 24 (2): 7-8.

Whitehead, Hal. 1990. *Voyage to the Whales*. Post Mills, Vermont: Chelsea Green Publishing.

Sustainable Seas Expeditions
Teacher Resource Book
EVALUATION FORM

Thank you for taking the time to complete this Evaluation Form. Your comments will help us improve the educational materials that we develop in the future.

1. **Circle the grade level(s) you teach:**

   6 7 8 9 10 11 12

2. **I teach (circle all that apply):**

   Geography Life Science Physical Science Earth Science Social Science

   Other: ______________________

3. **Rate the Teacher Resource Book in terms of quality.**

High quality				*Low quality*
1	2	3	4	5

4. **Rate the Teacher Resource Book in terms of usefulness.**

Very useful				*Not useful*
1	2	3	4	5

5. **The materials and activities are written at a level appropriate for a high school audience.**

Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
1	2	3	4	5

6. **These materials address my needs to teach to the local, state, and national standards in science and geography.**

   Agree *Disagree*

7. **The Investigations I used in my classroom were (circle all that apply):**

   Investigation 1: What are National Marine Sanctuaries?

   Investigation 2: A Closer Look at One Sanctuary

   Investigation 3: Planning an Expedition

   Investigation 4: Designing a Submersible

   Investigation 5: Using Charts to Explore Marine Sanctuaries (see Unit 2)

   Investigation 6: How Would an Oil Spill Affect a Marine Sanctuary? (see Unit 2)

   Investigation 7: Sea Turtle Lifecyles (see Unit 2)

8. **The amount of time my students spent on *Sustainable Seas Expeditions* was:**

0–1 hours	1–2 hours	3–5 hours	6–8 hours	8–10 hours	More than 10 hours

9. **Was there an *Expeditions* Student Summit in your area?** Yes No

If yes, did your students attend? Yes No

Did your students share their projects with others? Yes No

If yes, how valuable was this experience to their learning?

Very valuable				*Not very valuable*
1	2	3	4	5

10. **I am interested in participating in *Sustainable Seas Expeditions* again next year.**

Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
1	2	3	4	5

11. **Circle the parts of the *Sustainable Seas Expeditions* Teacher Resource Book that you feel need improvement:**

Background Information Investigations Teacher Resources

12. **Suggestions for improvement:**

13. **Did you notice student learning as a result of using these materials? Please explain your observations and conclusions.**

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Please send your completed Evaluation Form to:
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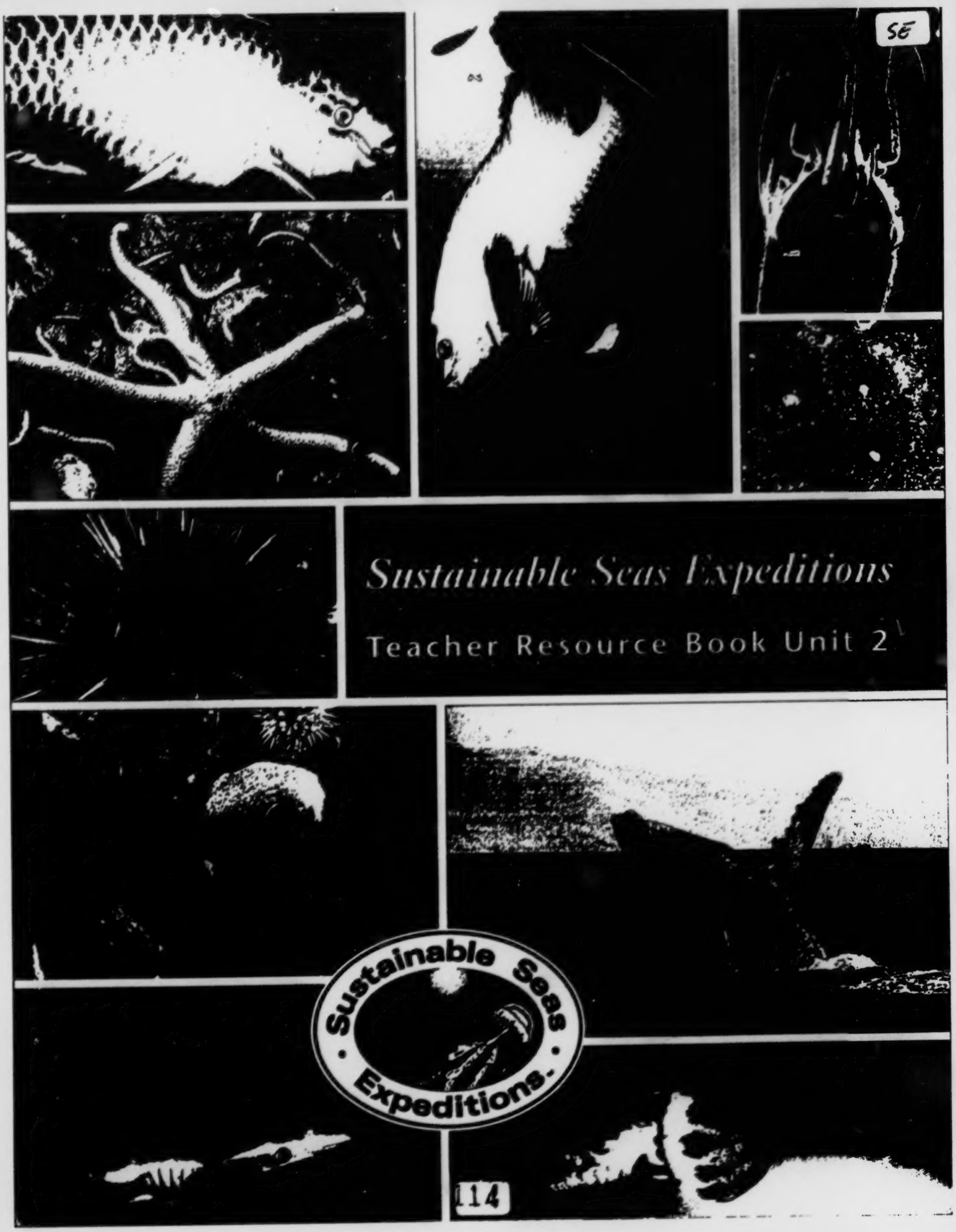

Sustainable Seas Expeditions

Teacher Resource Book Unit 2

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Sustainable Seas Expeditions

Teacher Resource Book
Unit 2

Sustainable Seas Expeditions

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National Marine Sanctuaries
NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce
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These materials were designed for grades 7–12 but may be adapted for other grade levels.

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Note to Teachers:

Investigations 1-4 can be found in *Sustainable Seas Expeditions Teacher Resource Book, Unit 1.* Unit 1 is available through the *Sustainable Seas Expeditions* office at the address listed at the bottom of page ii.

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INVESTIGATION 5

Using Charts to Explore Marine Sanctuaries

DeepWorker Underwater

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In this lesson, students learn to use mapping skills to locate features on a NOAA nautical chart of the Olympic Coast National Marine Sanctuary off the coast of Washington. In addition, students will simulate a dive of the DeepWorker submersible and conduct a transect of the bottom topography of the area. Students will also learn to find locations using latitude and longitude in a group activity.

BACKGROUND INFORMATION

NOAA's National Marine Sanctuaries (Unit 1, page 6)

DeepWorker (Unit 1, page 10)

ACTIVITIES

Navigating Using Nautical Charts

Using Maps for a National Marine Sanctuary Tour

LEARNING OBJECTIVES

Students will:

- Learn how to measure distance, longitude, latitude and depth using a portion of a nautical chart;
- Describe what personnel, tools, and supplies would be needed for a *Sustainable Seas Expeditions* mission to a national marine sanctuary;
- Use the Internet to find out information about a particular national marine sanctuary.

STANDARDS

Geography Standard 1:

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.

Geography Standard 2:

How to use maps to organize information about people, places and enviroments in a spatial context.

Science Education Standards:

Recognizing and developing abilities necessary to design and conduct scientific investigations.

ACTIVITY

Navigating Using Nautical Charts

Guiding Question

How are navigation and mapping skills used to plot a course and explore key features within the Olympic Coast National Marine Sanctuary?

Discussion

NOAA's Olympic Coast National Marine Sanctuary (OCNMS) spans 8,570 square kilometers (3,310 square miles) of marine waters off the rugged Olympic Peninsula coastline. The sanctuary averages approximately 56 kilometers (35 miles) seaward from the coast. Deeply carved canyons, wave-beaten rocky shores, sandy beaches, and sunken forests of giant kelp all provide habitats for a diverse array of fishes, invertebrates, birds, and marine mammals that feed and breed in the sanctuary. The reefs and shoals within the sanctuary provide numerous nooks and crannies for sea life to occupy. Here reside the world's largest octopus species, more than two dozen kinds of rockfish, many different sea stars and the brilliantly hued fish-eating anemone.

The jagged rocks that form the seastacks, islets, and offshore islands are mostly remnants of seafloor formed in the last 25 million years. As sea level has risen and fallen over the eons, coastal plains and wave-cut terraces have formed.

The maritime climate on the Olympic Peninsula reveals itself as powerful seasonal trends of waves, wind, and precipitation. Winter storm systems, formed thousands of miles away at sea, gain momentum as they track toward the Olympic Coast. Between October and March, periodic storms pound the coast with lashing rain, hurricane-force winds, and waves that have been recorded near 100 feet. Over 150 documented shipwrecks in and near the Sanctuary attest to the coast's sometimes fierce weather conditions.

In this lesson, you will simulate a DeepWorker dive in the OCNMS and will consider some of the equipment and logistical challenges in conducting a marine expedition.

Materials

- ☐ **Navigation Techniques Using Nautical Charts** handout (see pages 6-8)
- ☐ **Mission A or B** handout (one mission, A or B, per student, see pages 9-14)
- ☐ **Exploration Site Report** (two per student, see pages 15 and 16)
- ☐ **Exploration Site Cards** (one card per student, see pages 17 and 18)
- ☐ **OCNMS Map** (see page 19)
- ☐ **Chibahdehl Rocks to Neah Bay** section of NOAA chart #18480 (see page 20)
- ☐ **Umatilla Reef to Tskawahyah Island** section of NOAA chart #18480 (see page 21)

☐ Ruler or set of dividers

Optional:

☐ Compass

☐ Parallel ruler

☐ One NOAA chart #18480 covered with plastic or laminated. For information on ordering NOAA nautical charts, please visit: http://acc.nos.noaa.gov/naut/nautagents.html

☐ Two "dry erase" markers

Procedure

1 Set the stage for this activity by reading the material in the "Discussion" section to the students and showing them the **Olympic Coast National Marine Sanctuary Map** and boundaries. Have students review the following web pages if you have access to the Internet in your classroom: http://sustainableseas.noaa.gov/missions/olympic1/olympic1.html and http://www.ocnms.nos.noaa.gov/ Alternatively, you can print out the information on these web pages for students to review prior to beginning the lesson. This will help to familiarize them to the Olympic Coast area. Explain to the students that they will be doing a simulation of a dive with the DeepWorker submersible and have them review the information about DeepWorker's specifications on **Mission A** and **Mission B** handouts.

2 Ask if any of the students have done any navigation or related activities like orienteering where distance and compass bearings were used. Explain that when each team successfully navigates to a selected area, they will receive an **Exploration Site Card** that will give them information leading them to another site (off of the map) in one of the national marine sanctuaries. As a team, they must perform research that will locate the site, find the scientific significance of the site, draw a picture of what it might look like and fill out an **Exploration Site Report**.

3 To start, arrange the students into teams of three, and explain that each member of the team will have a specific role (see student handout sheet on page 8 for role descriptions).

- One member will be the Commanding Officer
- One member will be the Dive Supervisor
- One member will be the Chief Scientist/Pilot

4 Have each team read the **Navigation Techniques Using Nautical Charts** worksheet (see pages 8 and 9).

5 Give each team a map of the OCNMS and either the **Chibahdehl Rocks** (for **Mission A**, see page 9) or the **Umatilla Reef** (for **Mission B**, see page 12) portion of NOAA chart #18480. Take a few minutes to orient them with it. Point out the general location of the Olympic Coast National Marine Sanctuary on the **OCNMS Map** and have students locate Umatilla Reef and Chibahdehl Rocks. Tell students that the scale on the handout is in meters and that they will have to do some unit conversions in this activity. Point out that the numbers in the ocean areas of the charts are depths that are measured in fathoms. Give each team either **Mission A** or **Mission B** instructions.

6 In each mission the student teams will navigate from a drop off point to a specific location on the handout. They will determine the best time frame for launch and recovery of the submersible and latitude and longitude of the dive site. They will measure distance, speed and time to get to the desired location and will take currents into account as part of their mission planning.

7 When the student teams reach their destination, have them complete an **Exploration Site Report** describing what they would expect to see at the site.

8 When the student teams have completed their first **Exploration Site Report** and answered their mission questions, have them take an **Exploration Site Card**. This card will direct them to a special physical feature or object at a specific location in one of the national marine sanctuaries. They will have to do some research to complete a second **Exploration Site Report.**

Concluding the Lesson

Ask all students to share the information that they have gathered on their exploration site. Have them explain *WHY* this is an important site and what its significance is to the national marine sanctuary in which it is found.

Assessing Student Learning

Have students compare their **Exploration Site Reports** to the daily mission logs from the 1999 Sustainable Seas Mission at the Olympic Coast National Marine Sanctuary http://www.sustainableseas.noaa.gov/missions/olympic1/olympic1.html

Have students design a "new" exploration site for DeepWorker. Include as many aspects of exploration as possible. Have them explain WHY their new site is an important one.

Ask students to do further research (using the Internet and other sources) on their exploration site. Complete a report and give an oral presentation to the class.

Extension Activities

Ask students to complete a check-list of possible materials that a real expedition might need if it were to be at sea for two weeks.

Ask students to describe some of the technicians, scientists, and workers that would be needed for such a trip. Ask the students to try and estimate the cost for such a trip.

Ask the students to think about and describe what some of the emergency procedures might be if something were to go wrong with the DeepWorker submersible such as entanglement in a line underwater, problems with the electrical system or batteries, or running out of oxygen.

Have students do further research on what types of ships sailed in the OCNMS area in the past (50 or 100 years ago). What types of expeditions were

conducted? Are there any significant shipwrecks in the area? What instruments were used for these expeditions? How do they compare to today's technologies?

Look at the DeepWorker video for Olympic Coast NMS in the video gallery at http://sustainableseas.noaa.gov/aboutsse/media/media.html This video was taken at Umatilla Reef in the same location as Mission B. What types of marine life can students identify in the video? What types of underwater features do they see?

Introduction:

A chart is a miniature graphic representation of a part of the earth's curved surface transferred to a flat surface. A nautical chart shows the natural and man-made features of a specific boating area, including safe channels as well as hazards to navigation. In this activity, you will be using a portion of a nautical chart for the Olympic Coast National Marine Sanctuary, either the **Chibahdehl Rocks to Neah Bay** handout or the **Umatilla Reef to Tskawahyah Island** handout, and a map showing the Olympic Coast National Marine Sanctuary.

Latitude and Longitude:

The uniform grid system makes it possible to locate any point on earth. This system consists of two sets of imaginary lines on the earth's surface: one set, called parallels of latitude, run east-west parallel to the equator; the other set, called meridians of longitude, run north-south through the poles. Geographic coordinates are measured in terms of degrees. By international agreement, meridians of longitude are measured east or west of the prime meridian, which passes through Greenwich, England (0° longitude is about 5 miles east from the center of London). The longitude of any position on earth is described as "X" degrees east or west of Greenwich, to a maximum in either direction of 180°. Parallels of latitude are measured in degrees north or south of the equator, from 0° at the equator to a maximum of 90° at the poles.

On your handouts, which show a section of the Olympic Coast National Marine Sanctuary, latitude numbers run along the sides of the handout and longitude numbers run along the bottom. To determine the latitude and longitude of a point on the chart, use a ruler or set of dividers to draw straight lines from the latitude scale on the side of your chart and the longitude scale on the bottom of the chart to your selected point. Your lines will be perpendicular to each other and will intersect at the point where you want to measure the latitude and longitude. For example, the approximate latitude and longitude of Koitlah Point on the **Chibahdehl Rocks to Neah Bay** handout is 48°23'17" N latitude, 124°38'15" W longitude.

Depth in Soundings:

Numbers indicating water depths are prominent and important features of a chart. They are established by soundings. Soundings are created by sending sound waves from a ship into the water and measuring the time it takes for them to bounce off the ocean floor and return. The depths on the charts you will use for this activity are shown in fathoms (a fathom is 6 feet or 1.82 meters).

Tidal Current

As the tide rises and falls, there is a horizontal movement of water, termed a tidal current. This current is called flood when the flow is toward land and ebb when the flow is toward the sea. Tidal currents, like tides, can vary significantly—from less than half a knot (kt) to 6 knots or more. The table below is a sample current table for the Strait of Juan de Fuca. Find the Strait of Juan de Fuca on the **Map of the Olympic Coast National Marine Sanctuary** handout. Note that in this region a flood tide flows east and an ebb tide flows west. At slack tide there is no tidal current. The tidal current needs to be taken into consideration for areas in the region of the Strait of Juan de Fuca (Chibahdehl Rocks, for example). The tidal current is negligible out on the open coast of the Olympic Peninsula (Umatilla Reef).

Sample Current Table for the Strait of Juan de Fuca:

Time	Current
6:00 am	1.3 kt ebb
6:30 am	1.7 kt ebb
7:00 am	1.9 kt ebb
7:30 am	2.1 kt ebb
8:00 am	2.3 kt ebb
8:30 am	2.3 kt ebb
9:00 am	2.3 kt ebb
9:30 am	2.1 kt ebb
10:00 am	1.9 kt ebb
10:30 am	1.6 kt ebb
11:00 am	1.2 kt ebb
11:30 am	0.8 kt ebb
12:00 pm	0.3 kt ebb
12:30 pm	0.1 kt slack
1:00 pm	0.5 kt flood
1:30 pm	0.9 kt flood
2:00 pm	1.1 kt flood
2:30 pm	1.3 kt flood
3:00 pm	1.5 kt flood
3:30 pm	1.5 kt flood
4:00 pm	1.4 kt flood
4:30 pm	1.2 kt flood

To convert between units, use the following equations:

1 statute (land) mile = 0.87 nautical miles
1 nautical mile = 1,852 meters
1 statute mile = 1,609 meters
1 fathom = 6 feet
1 foot = 0.3048 meters
1 meter = 3.281 feet

1 nautical mile = 1.15 statute miles
1 meter = 0.00054 nautical miles
1 meter = 0.00062 statute miles
1 foot = 0.16667 fathoms
1 meter = 0.5468 fathoms
1 fathom = 1.829 meters

Speed:

Speed is the number of units of distance traveled in a specified unit of time. The basic unit of speed measured in the ocean is a knot, which is a nautical mile per hour.

Distance (D), Time (T), and Speed (S) Calculations:

D = ST Distance (nm) = Speed (knots) x Time (hrs)
S = D/T Speed (knots) = Distance (nm) / Time (hrs)
T = D/S Time (hrs) = Distance (nm) / Speed (knots)

Mission Operations Team:

Commanding Officer

The Commanding Officer of the NOAA Ship *McArthur* has the authority over all operations relating to safety of the vessel and safety of all assigned personnel on board. Before the DeepWorker submersible is launched from the ship, both the Commanding Officer and Dive Supervisor must agree that conditions are acceptable for safe launch and recovery of the submersible.

Dive Supervisor

The Dive Supervisor is responsible for safe and efficient submersible operations at sea and shares responsibility for the safe launch and recovery of the submersible with the Commanding Officer. The Dive Supervisor will request from the Commanding Officer, the course, speed and positioning of the ship to ensure safety and efficiency of submersible operations. The Dive Supervisor will review and approve all proposed pilots and their qualifications, as well as the locations, profiles and procedures related to diving the DeepWorker submersible.

Chief Scientist/Pilot

The Pilot is the person who physically controls the submersible. The Pilot is responsible to the Dive Supervisor for all aspects of submersible operations as required to carry out the assigned mission. The Chief Scientist develops and coordinates the implementation of the cruise plan.

MISSION A: CHIBAHDEHL ROCKS (page 1 of 3)

Information:

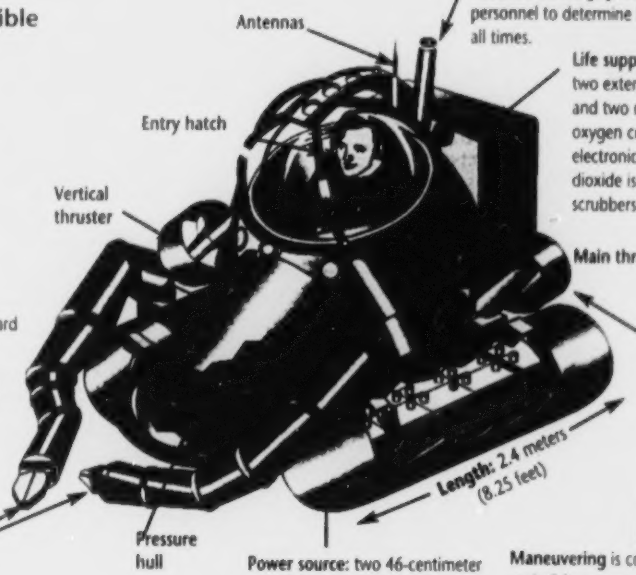
A) The NOAA ship *McArthur* has a cruising speed of 10-12 knots. It carries the DeepWorker submersible and all support staff and scientists.

B) The DeepWorker submersible has the following specifications:

DeepWorker 2000 Submersible

SPECIFICATIONS
Weight in air: 1,600 kilograms (1.6 tons)
Operating depth: 600 meters (2,000 feet)
Payload: 136 kilograms (250 pounds), including pilot
Life Support: 80 hours
Speed: 4 knots maximum
Crew: 1 pilot

COMMUNICATION SYSTEMS include a modified Imaginex sonar, which allows standard scanning and ultra-high resolution for short range. Ocean sounds are recorded with a directional hydrophone. Video cameras allow the pilot to record the dive. VHF and thru-water communications allow contact with surface support personnel.



Acoustic tracking system permits surface personnel to determine location of sub at all times.

Life support systems include two external oxygen cylinders and two redundant, mechanical oxygen controllers with internal electronic monitoring. Carbon dioxide is removed by two scrubbers.

The **robotic arms** are hydraulic-powered manipulators that can extend 3.6 meters (12 feet).

Power source: two 46-centimeter (18-inch) diameter battery pods, each containing 10 high-amps, deep-cycle batteries.

Maneuvering is controlled by two main 1-horse-power thrusters plus two angled vertical thrusters for lateral movement. A 3-cubic-meter (100-cubic-foot) ballast air tank provides additional control of depth.

Note: A vacuum is pulled on the DeepWorker cabin to -1 psi (pound per square inch) just before the DeepWorker is launched from the ship. Cabin pressure is monitored during the dive and should stay below zero (at least -0.5 psi)

Mission:

Your DeepWorker drop-off point is just offshore of Chibahdehl Rocks. Chibahdehl Rocks are a series of submerged sedimentary rock ledges. Schools of rockfish, lingcod and a variety of invertebrates including sea anemones, sea stars, and sea urchins can be found here. Rock ledges are hiding places for wolfeels, greenlings and other fish. Visibility is limited here because of the high density of marine phytoplankton. The shallow ledges are accessible by scuba diving, but the deeper areas remain unexplored. The NOAA Ship *McArthur* will anchor offshore in 60 fathoms of water for the duration of your dive. A small, Rigid Hull, Inflatable Boat (RHIB) will tow DeepWorker to its point of descent, and be responsible for communications with the DeepWorker while it is underwater.

1) What is the approximate latitude and longitude of Chibahdehl Rocks dive site?

2) Look at the current table (see page 7) and determine what the best time frame would be for your dive. Note it takes about 1/2 hour to launch the submersible and 1/2 hour to recover it. You want to make sure that the current has the least effect on your submersible speed. Also, operational policy limits diving to times when the tidal current is 2 knots or less. You have 1 hour to spend underwater. Remember that DeepWorker travels at approximately 3 knots with a slack current.

Fill in the times in for the following activities:

Begin launch:

Begin dive (leave surface):

Return to surface:

Begin recovery:

3) Assuming that DeepWorker's speed is 3 knots, what is the speed in meters/hour (you will need to convert nautical miles/hour (knots) to meters/hour)?

4) Place an "X" on your chart next to the "(21)" near Chibahdehl Rocks. Write "begin dive" and the time at the "X". Once you begin your dive, travel north on an underwater transect for approximately 1,250 meters. Place an "X" on your chart and write "turnaround point". During this transect, what is the depth range and maximum depth in both feet and meters (note your chart shows depth in fathoms, so you will need to use the conversion table) that you covered on your dive to the "turnaround point"? What is the approximate latitude and longitude at the "turnaround point"?

Assuming you begin your transect at 12:00 p.m., and the fact that the maximum speed of DeepWorker is 3 knots with no current, how long will it take to travel 1,250 meters? How many nautical miles is 1,250 meters?

Are there any potential obstacles on your route that you may need to consider when conducting your dive?

MISSION A: CHIBAHDEHL ROCKS (page 3 of 3)

5) At the "turnaround point" you descend to the bottom. The Dive Supervisor asks you to surface due to some problems with the underwater communications system. How long will it take to surface given that the maximum allowed ascent rate for the DeepWorker is 100 feet/minute? The problem is resolved when you arrive at the surface, and you are again given permission to dive. How long will it take to get back to the RHIB? What is the total dive time (include ascent and descent times)?

6) Complete an **Exploration Site Report** of what you would expect to see during your dive at Chibahdehl Rocks.

Stop: Show your teacher your chart with its plotted points and your answers to the above questions. Get his/her permission to proceed.

Now that you have completed your mission, your team should be congratulated for its excellence in planning and navigation skills. You are now entering Phase II of this lesson. You can take an **Exploration Site Card**. It will list a subject in one of the national marine sanctuaries. You must do some research using the Internet and find out more information about your subject and your exploration site. Complete an **Exploration Site Report** that corresponds to your assignment. Draw what you would expect to see at your exploration site and what your DeepWorker instrument panel might look like if you were to conduct a dive there.

Information:

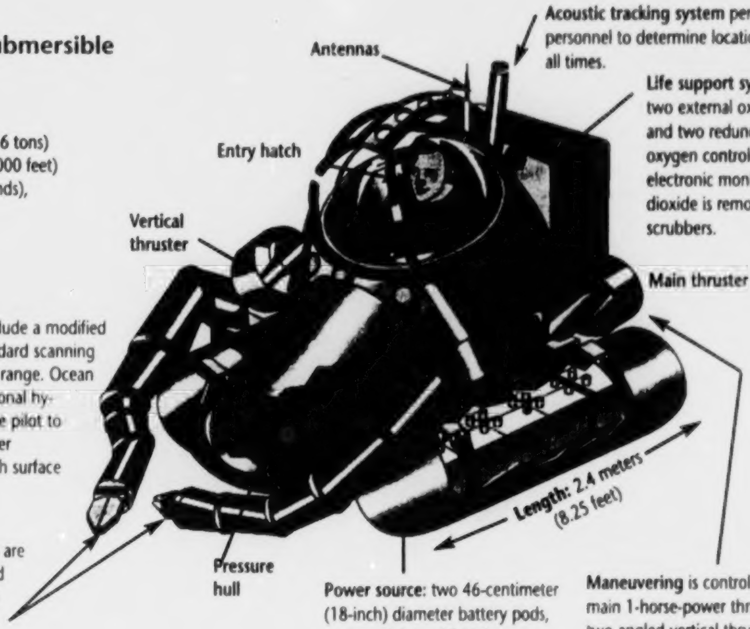
A) The NOAA ship *McArthur* has a cruising speed of 10-12 knots. It carries the DeepWorker submersible and all support staff and scientists.

B) The DeepWorker submersible has the following specifications:

DeepWorker 2000 Submersible

SPECIFICATIONS
Weight in air: 1,600 kilograms (1.6 tons)
Operating depth: 600 meters (2,000 feet)
Payload: 136 kilograms (250 pounds), including pilot
Life Support: 80 hours
Speed: 4 knots maximum
Crew: 1 pilot

COMMUNICATION SYSTEMS include a modified Imaginex sonar, which allows standard scanning and ultra-high resolution for short range. Ocean sounds are recorded with a directional hydrophone. Video cameras allow the pilot to record the dive. VHF and thru-water communications allow contact with surface support personnel.



Acoustic tracking system permits surface personnel to determine location of sub at all times.

Life support systems include two external oxygen cylinders and two redundant, mechanical oxygen controllers with internal electronic monitoring. Carbon dioxide is removed by two scrubbers.

The **robotic arms** are hydraulic-powered manipulators that can extend 3.6 meters (12 feet).

Power source: two 46-centimeter (18-inch) diameter battery pods, each containing 10 high-amps, deep-cycle batteries.

Maneuvering is controlled by two main 1-horse-power thrusters plus two angled vertical thrusters for lateral movement. A 3-cubic-meter (100-cubic-foot) ballast air tank provides additional control of depth.

Note: A vacuum is pulled on the DeepWorker cabin to -1 psi (pound per square inch) just before the DeepWorker is launched from the ship. Cabin pressure is monitored during the dive and should stay below zero (at least -0.5 psi)

Mission: Umatilla Reef

Your DeepWorker drop-off point is near Umatilla Reef. Umatilla Reef is the seaward extension of Cape Alava, the westernmost point in the lower 48 states. Sand bottom and cobble surround the reef. The reef itself is composed of boulders. Basket stars and sea anemones can be found here as well as lingcod, rockfish, and other marine life. The NOAA Ship *McArthur* will anchor here for the duration of your dive. A small, Rigid Hull Inflatable Boat (RHIB) will tow DeepWorker to its point of descent, and be responsible for communications with the DeepWorker while it is underwater.

1) What is the approximate latitude and longitude of the Umatilla Reef dive site?

2) Determine what the best time frame would be for your dive (note the tidal current is negligible on the open coast). It takes about 1/2 hour to launch the submersible and 1/2 hour to recover it.

You have 1 hour to spend underwater. Remember that DeepWorker travels at approximately 3 knots with a slack current.

Fill in the times in for the following activities:

Begin launch:

Begin dive (leave surface):

Return to surface:

Begin recovery:

3) DeepWorker speed is 3 knots. What is your speed in meters/hour (you will need to convert nautical miles/hour (knots) to meters/hour)?

4) Place an "X" on your chart next to the "f" in Umatilla Reef. Write "begin dive" and the time at the "X". Once you begin your dive, travel north on an underwater transect for 1,500 meters. Place an "X" on your chart and write "turnaround point". During this transect what is the depth range and maximum depth in both feet and meters (note your chart shows depth in fathoms, so you will need to use the conversion table) that you covered on your dive to the "turnaround point"? What is the approximate latitude and longitude at the "turnaround point"?

Assuming the maximum speed of DeepWorker is three knots, how long will it take to travel 1,500 meters? How many nautical miles is 1,500 meters?

5) At the "turnaround point" you descend to the bottom. The Dive Supervisor asks you to surface due to some problems with the underwater communications system. How long will it take to surface given that the maximum allowed ascent rate for the DeepWorker is 100 feet/minute? The problem is resolved when you arrive at the surface, and you are again given permission to dive.

MISSION B: UMATILLA REEF (page 3 of 3)

How long will it take to get back to the RHIB? What is the total dive time (include ascent and descent times)?

6) Complete an **Exploration Site Report** of what you would expect to see during your dive at Umatilla Reef.

Stop: Show your teacher your chart with its plotted points and your answers to the above questions. Get his/her permission to proceed.

Now that you have completed your mission, your team should be congratulated for its excellence in planning and navigation skills. You are now entering Phase II of this lesson. You can take an **Exploration Site Card**. It will list a subject in one of the national marine sanctuaries. You must do some research using the Internet and find out more information about your subject and your exploration site. Complete an **Exploration Site Report** that corresponds to your assignment. Draw what you would expect to see at your exploration site and what your DeepWorker instrument panel might look like if you were to conduct a dive there.

EXPLORATION SITE REPORT (page 1 of 2)

1) Use maps and other resources to find out all that you can about your exploration site.

   National Marine Sanctuary Program web site: www.sanctuaries.nos.noaa.gov

   NOAA's Sustainable Seas web site: www.sustainableseas.noaa.gov

   National Geographic's *Sustainable Seas Expeditions* web site: www.nationalgeographic.com/seas/

2) Draw what you would expect to see at your exploration site. The view should be from inside DeepWorker looking out. Use the "square" as your window.

3) Draw an instrument panel of what you would expect to see in DeepWorker. Parameters that might be measured inside DeepWorker are: depth, oxygen percent, carbon dioxide percent, battery volts, speed, cabin pressure, etc.

EXPLORATION SITE REPORT (page 2 of 2)

Names in your group: **Date**

Exploration Site (name, latitude and longitude):

Seas (height and direction)

Current (none, weak, strong) **and direction**

Visibility (m)

Surface temperature (°C and °F)

Bottom temperature (°C and °F)

Habitat type (circle all that apply):

Mud (very fine) Silt (fine) Sand (coarse) Rubble/cobble Rock outcrop
Ridges Pinnacles Drowned reef Living reef Seamount
Vent Other (describe):

Relief (height)

0-1M features: 1-3M features 3-10M features >10M features:

Marine life observations:

Fish observed Invertebrates observed Marine Mammals observed

Human activities (circle all that apply):

Recreational fishing Commercial fishing Pleasure boating Diving/snorkeling
Shipping Overflights Whale watching

Human impacts observed (circle all that apply):

Anchor damage Fishing Gear
Other (describe):

EXPLORATION SITE CARDS

EXPLORATION SITE CARD	**EXPLORATION SITE CARD**
EXPLORATION SITE CARD	**EXPLORATION SITE CARD**
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EXPLORATION SITE CARDS

Humpback Whale
Hawaiian Islands Humpback Whale National Marine Sanctuary
http://www.hihwnms.nos.noaa.gov
Hawaii Whale Research Foundation
http://www.hwrf.org
Whale Watching web site
http://www.physics.helsinki.fi/whale

Kelp Forest

Channel Islands National Marine Sanctuary

http://www.cinms.nos.noaa.gov
Channel Islands National Park
http://www.nps.gov/chis
http://www.mbayaq.org/efc/efc_hp/hp_kelp.asp

Brine Seep and Salt Domes

Flower Garden Banks National Marine Sanctuary
http://sustainableseas.noaa.gov/missions/flower1/background/maps.html
http://www.flowergarden.nos.noaa.gov/about/charact.html
http://sustainableseas.noaa.gov/missions/flower1/background/natural_setting.html

USS *Monitor*

Monitor National Marine Sanctuary

http://monitor.nos.noaa.gov/
Mariners Museum—http://www.mariner.org

Cordell Bank

Cordell Bank National Marine Sanctuary

http://www.sanctuaries.nos.noaa.gov/oms/omscordell/omscordell.html
http://sustainableseas.noaa.gov/missions/cordell1/cordell1.html

Ashy Storm-Petrel

Gulf of the Farallones National Marine Sanctuary
http://www.gfnms.nos.noaa.gov/
http://sustainableseas.noaa.gov/missions/farallones1/farallones1.html
http://www.audubon.org/bird/watch/ash/ash.html

Tortugas Ecological Reserve

Florida Keys National Marine Sanctuary

http://www.fknms.nos.noaa.gov/tortugas/
http://www.fknms.nos.noaa.gov/tortugas/what-special/index.html

Monterey Canyon

Monterey Bay National Marine Sanctuary

http://www.mbnms.nos.noaa.gov
http://www.mbari.org/
http://www.mbayaq.org/

Loggerhead Sea Turtle

Gray's Reef National Marine Sanctuary

http://www.graysreef.nos.noaa.gov
http://sustainableseas.noaa.gov/missions/grays1/background/turtles.html

Stellwagen Bank

Stellwagen Bank National Marine Sanctuary

http://vineyard.er.usgs.gov/info.html
Stellwagen Bank SSE Mission
http://sustainableseas.noaa.gov/missions/stellwagen1/stellwagen1.html

Fringing Tropical Coral Reef

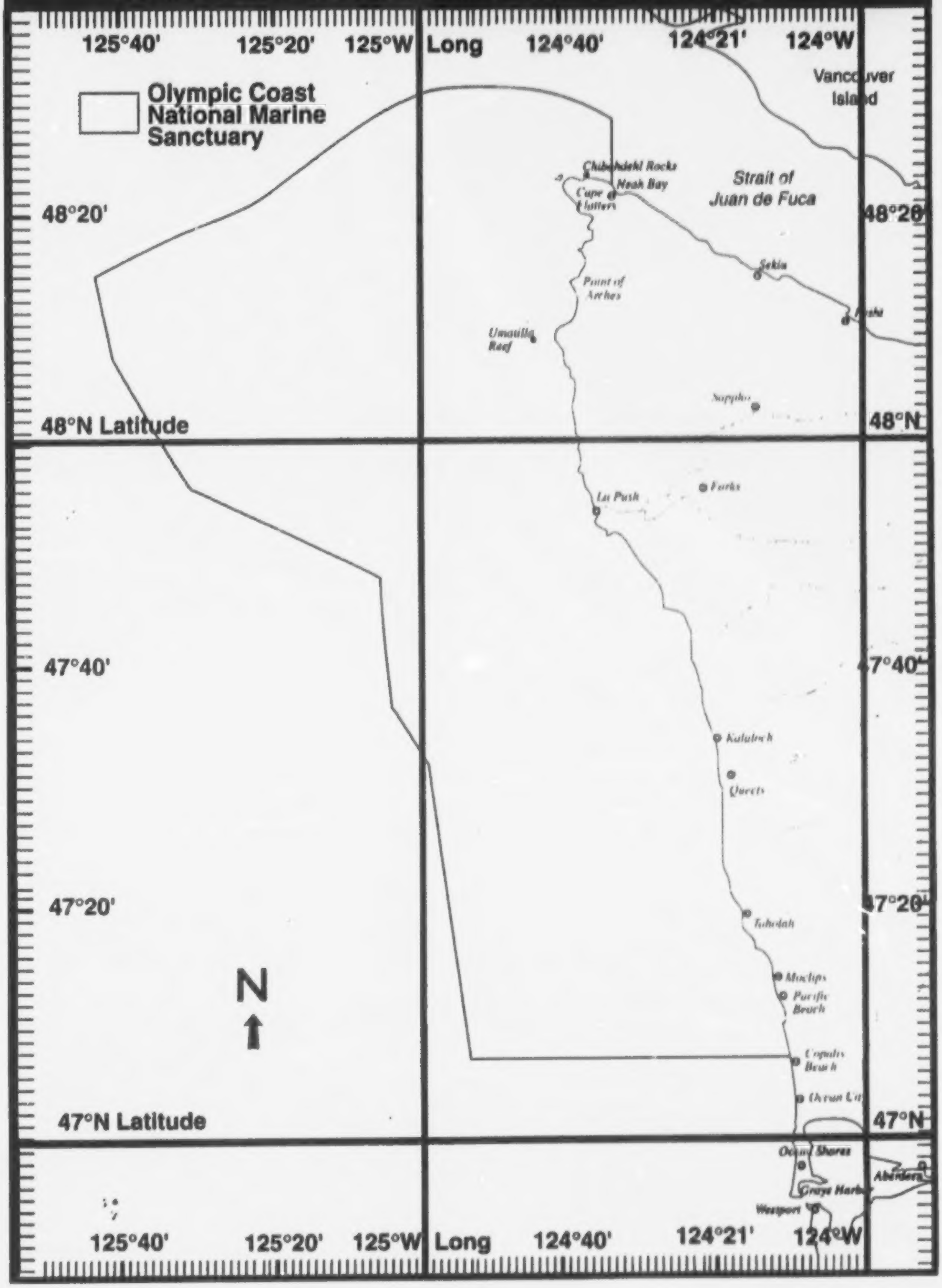
Fagatele Bay National Marine Sanctuary
http://www.fbnms.nos.noaa.gov

Coral Reef Alliance
http://www.coral.org

***The Grecian* Shipwreck**

Thunder Bay National Marine Sanctuary
http://www.glerl.noaa.gov/glsr/thunderbay/shipwrecks/known.html
http://www.glerl.noaa.gov/glsr/thunderbay/shipwrecks/grecian.html

OLYMPIC COAST NATIONAL MARINE SANCTUARY (OCNMS) MAP


125°40'
125°20'
125°W
Long
124°40'
124°21'
124°W
Vancouver Island
Olympic Coast National Marine Sanctuary
Chibahdehl Rocks
Neah Bay
Cape Flattery
Strait of Juan de Fuca
48°20'
Sekiu
Point of Arches
Pysht
Umatilla Reef
Sappho
48°N Latitude
48°N
La Push
Forks
47°40'
Kalaloch
Queets
47°20'
Taholah
N
Moclips
Pacific Beach
Copalis Beach
Ocean City
47°N Latitude
47°N
Ocean Shores
Aberdeen
Grays Harbor
Westport

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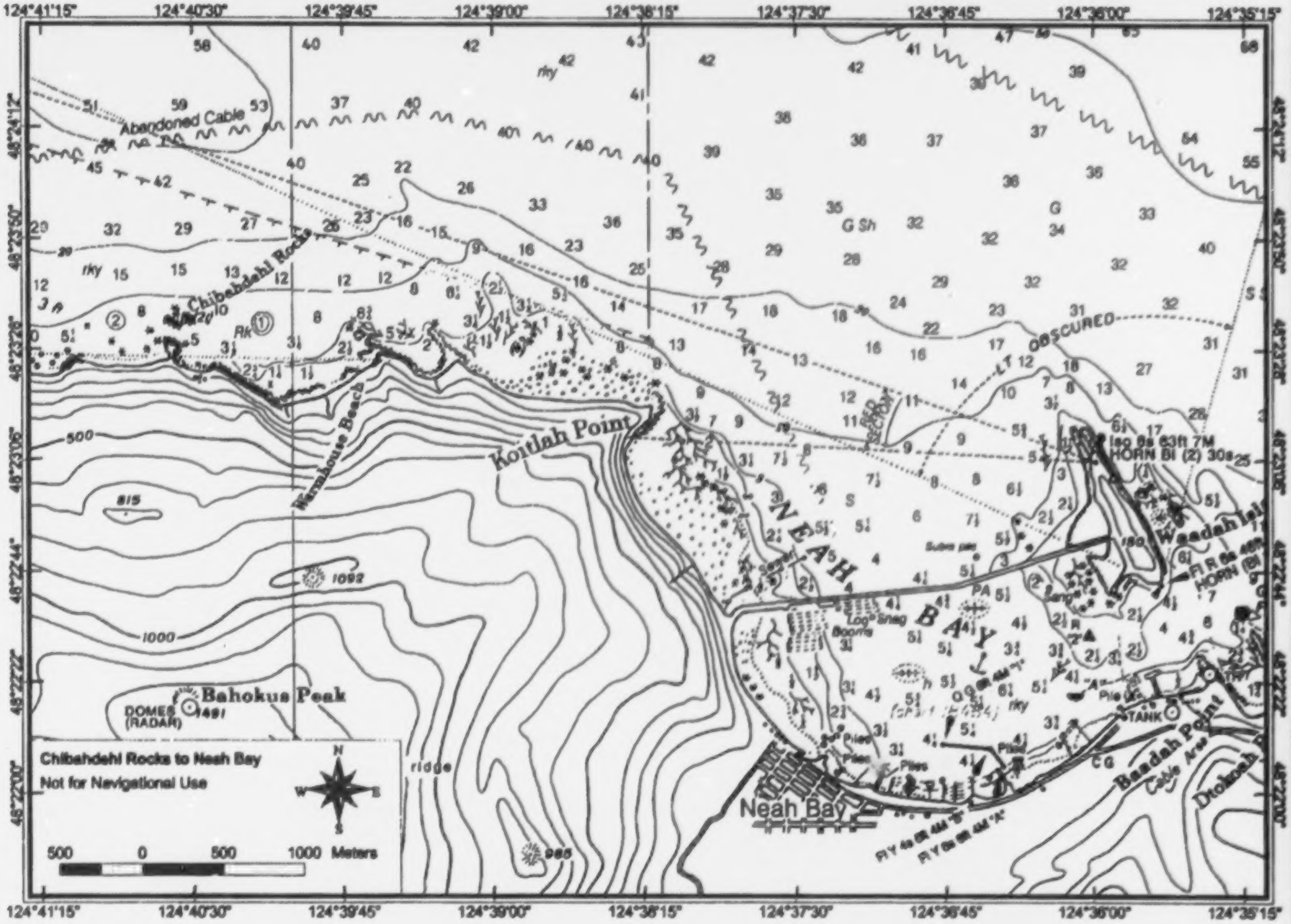
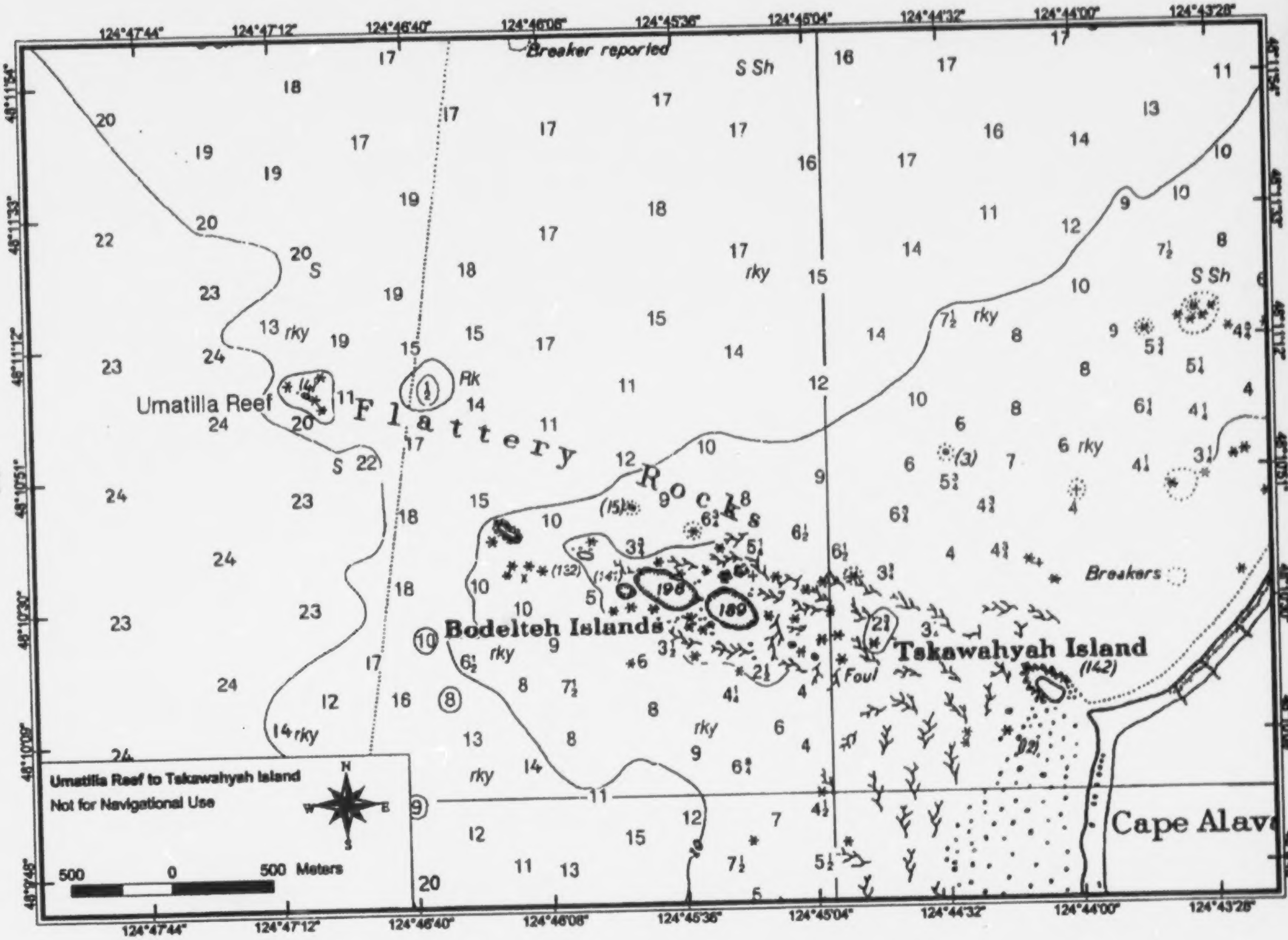

Chibahdehl Rocks to Neah Bay
Not for Navigational Use
N
S
E
W
500 0 500 1000 Meters
Abandoned Cable
Chibahdehl Rocks
Warmhouse Beach
Koitlah Point
NEAH BAY
Neah Bay
Waadah Isl
Baadah Point
Diobsud
Bahokus Peak
DOMES (RADAR)
1491
815
1092
1000
500
965
ridge
LT OBSCURED
RED SECTOR
Iso 6s 63ft 7M
HORN Bl (2) 30s
Fl R 6s 48ft
HORN (B)
TANK
Cable Area
Piles
Log Snag
Booms
F R Y 4s 6ft 4M "B"
F R Y 5s 6ft 4M "A"
Subm piles
G Sh
rky
Rk
124°41'15"
124°40'30"
124°39'45"
124°39'00"
124°38'15"
124°37'30"
124°36'45"
124°36'00"
124°35'15"
48°24'12"
48°23'50"
48°23'28"
48°23'06"
48°22'44"
48°22'22"
48°22'00"


124°47'44"
124°47'12"
124°46'40"
124°46'08"
124°45'36"
124°45'04"
124°44'32"
124°44'00"
124°43'28"
48°11'54"
48°11'33"
48°11'12"
48°10'51"
48°10'30"
48°10'09"
48°9'48"
Breaker reported
S Sh
S
rky
Rk
Umatilla Reef
Flattery Rocks
(15)
(132)
(14)
198
189
Bodelteh Islands
Foul
Tskawahyah Island
(142)
(3)
Breakers
Cape Alav
Umatilla Reef to Tskawahyah Island
Not for Navigational Use
N
W
E
S
500
0
500
Meters

ACTIVITY

Using Maps for a National Marine Sanctuary Tour

Guiding Question

What is latitude and longitude and how can they be used to locate places on a map or a globe?

Discussion

This activity is designed as an introduction to where the national marine sanctuaries can be found in the United States and is targeted for students in grades 4-12. The focus of this activity is to link geography, use of maps and the development of mental maps (an individual's internalized representation of aspects of the Earth's surface) in a fun and engaging manner. By changing the content of this activity from national marine sanctuaries to other local points of interest, the concepts can be used to teach about a wide variety of geographic areas. This activity provides an excellent review of principles that engage students in how to use geography to read maps and locate specific national places of interest.

Materials

☐ 19 index cards (or squares of paper) of five different colors, in the following groups:

color 1 (yellow) = 4 cards
color 2 (blue) = 3 cards
color 3 (red) = 2 cards
color 4 (white) = 7 cards
color 5 (green) = 3 cards

☐ **Teacher Guide for Sanctuary Tour**

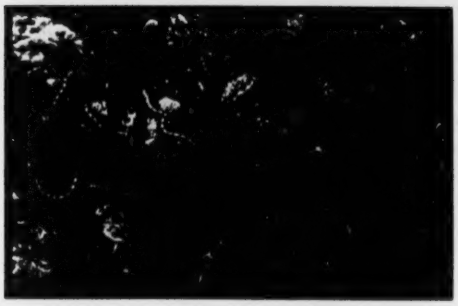
☐ Several wall maps—World, United States, North America, Pacific Ocean or Rim (large format atlases or classroom globes may also be useful)

☐ **National Marine Sanctuary Sites information** (for review, discussion, and follow-up of this activity, see Unit 1, page 16)

Procedure

1 Note that the first entry on the **Teacher Guide** is an approximate latitude/longitude location (47°N 92°W), and that the last entry is a place name (CHANNEL ISLANDS NMS). Beginning with the top of the list—47°N 92°W, write each latitude and longitude location/place on one of the nineteen cards. Use the color sequence listed in the **Teacher Guide**. On the back of each card, write the corresponding letter listed in the **Teacher Guide**. Have wall maps of the United States, North America, the World and Pacific Ocean (and/or globes and large-format atlases) scattered about the room, available for student use.

2 Place cards, with locations/place names facing up, on a table or desk. Hand a student the first card on the tour, which reads 47°N 92°W. State that this is the starting point of the "National Marine Sanctuaries Tour," and that each card, except this first one and the last one, includes BOTH a set of latitude and



longitude coordinates AND a place name. Explain that these coordinates and place names do not match on a single card. However, one student has the place name which matches a latitude/longitude from someone elses card, AND a different person has the latitude/longitude coordinates which match a specific place name. Have eighteen other students each pick a card. If you have more than eighteen students, include other students as observers or as "free-lance guides" to help match locations with coordinates and to arrange students in the hoped-for loop. Alternatively, you may pair up students as needed to work with a single card. You can also add more location/place cards along the tour route from Duluth to Channel Islands NMS, e.g, other Great Lakes ports, U.S. Virgin Islands, Puerto Rico; additional Hawaiian or Alaskan places, but the "phrase" used in this activity to provide the "surprise" check for students would need to be replaced with another. Don't tell the students WHY there are different card colors or WHY there are letters on the back of each card; save that for later. The "phrase" developed after the students line up correctly is the surprise "check" on their work.

3 Tell students to try to arrange themselves in the proper tour order, by geographic location starting from Duluth, MN to Channel Islands, CA, by consulting the maps/atlases/globes around the room, and by questioning other students about their place names and locations. You might want to place the student with the first and last cards in specific "beginning and ending" spots in the room. These locations should also correspond to approximate locations on a map as viewed from above the room (in fact, by indicating a rough latitude/longitude grid out on the floor of your classroom for the portion of the world in which you're working, you can sharpen their mental maps). Students will likely struggle a bit at first with this, and guidance should be offered, but as long as they know their task, they should begin to close the links of the tour "chain" one by one, as they match latitude and longitude coordinates and place names to shape a mental map of the sanctuary system.

4 When most students have found their matches (some may still be struggling), ask them to see if they are grouped with other students who have similar color cards. They should be. Give them time to rearrange, if necessary. Then ask if they can spell out a word with the letters on the backs of their like-colored cards. They should be able to do so, if they are in the proper tour order. Give them time to rearrange, if necessary. Ask each like-color group, in order from the first, to state its word. If the class National Marine Sanctuaries Tour is in order, the letters on back should spell out: "From Sea to Shining Sea" (19 letters, no spaces), an appropriate motto for the nation's far-flung string of important marine sanctuaries.

5 Ask students, in order from beginning to end of the tour, to give their latitude and longitude and place names (you may point these out on a world or North America map as they are mentioned, possibly with an overhead transparency map on which the locations have been

mapped in advance). With students still in the chain or loop, discuss the problems encountered with finding their links, and in constructing the route for this mental map tour of the sanctuaries.

6 For immediate follow-up, as a homework assignment, or for next-day discussion, ask students to think of one or more possible natural or cultural resources that is found in the national marine sanctuary listed on their card (e.g., whales, corals, ship wreck, etc.—these could be researched). Also, ask each student or group to think of one or more possible threats to that resource (over-harvest, pollution, treasure hunters, etc.—these could also be researched). This could easily lead to a broader discussion of why the marine sanctuaries are important to protect, why they're where they are, and what other marine resources need to be protected.

Extension Activity

Make up another "tour" for Pacific Rim tectonic/volcanic activity, for West or East Coast U.S. or Great Lakes ports, for countries of the world or for world capitals/largest cities, or for any region—your state's significant places. Think of an expression which fits the number of letters and the flavor of the topic.

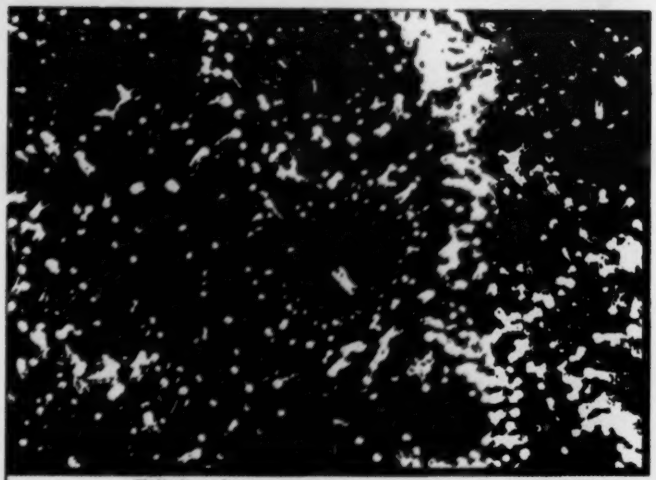
Acknowledgements

This activity is based on the linked-card "tour" method suggested by Tom Kropidlowski, who teaches science and geography at Seton Catholic Middle School, in Neenah, Wisconsin.

Mark H. Bockenhauer, Ph.D.
Assistant Professor of Geography
St. Norbert College
De Pere, Wisconsin 54115

TEACHER GUIDE FOR SANCTUARY TOUR CARDS

FRONT OF CARD	COLOR	LETTER ON BACK
47°N 92°W	Yellow	F
DULUTH 45°N 83°W	Yellow	R
THUNDER BAY NMS 48°N 60°W	Yellow	O
GULF OF ST. LAWRENCE 42°N 70°W	Yellow	M
STELLWAGEN BANK NMS 35°N 75°W	Blue	S
MONITOR NMS 31°N 80°W	Blue	E
GRAY'S REEF NMS 24°N 81°W	Blue	A
FLORIDA KEYS NMS 27°N 93°W	Red	T
FLOWER GARDEN BANKS NMS 9°N 79°W	Red	O
PANAMA CANAL 14°S 170°W	White	S
FAGATELE BAY NMS 21°N 157°W	White	H
HAWAIIAN ISLANDS HUMPBACK WHALE NMS 61°N 150°W	White	I
ANCHORAGE 48N 123°W	White	N
NORTHWEST STRAITS 48°N 124°W	White	I
OLYMPIC COAST NMS 38°N 123°W	White	N
CORDELL BANK NMS 37°N 122°W	White	G
GULF OF THE FARALLONES NMS 36°N 122°W	Green	S
MONTEREY BAY NMS 34°N 119°W	Green	E
CHANNEL ISLANDS NMS	Green	A



Club-tipped sea anemones LAURA FRANCIS

INVESTIGATION 6

How would an Oil Spill Affect a Marine Sanctuary?

In this investigation, students consider the criteria used to assess damage to natural resources and discuss possible mitigation measures that might be used when a large scale environmental threat, such as an oil spill, occurs.

BACKGROUND INFORMATION

NOAA's National Marine Sanctuaries (Unit 1, page 6)

ACTIVITY

Danger—Oil Spill in the Sanctuary!

LEARNING OBJECTIVES

Students will:

- Learn what the terms resources and stakeholders mean;
- Investigate how human impact, in this case an oil spill, can affect sanctuary resources;
- Communicate, in a mock public meeting, how to most effectively mobilize people and resources to protect the sanctuary;
- Be introduced to Geographic Information Systems (GIS) technology.

STANDARDS

Geography Standard 3

How to analyze spatial organization of people, places, and environments on the Earth's surface

Geography Standard 18

How to apply geography to interpret the present and plan for the future

Science Education Standards

Developing self-directed learners

How to read and interpret graphic and geologic maps

ACTIVITY

Danger—Oil Spill in the Sanctuary!

Guiding Question

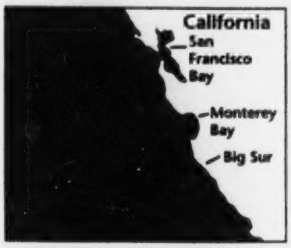
What sanctuary resources might be affected in the event of a large-scale oil spill?

Materials

- ☐ **NOAA's National Marine Sanctuaries** for each student group (see Unit 1, page 6)
- ☐ **Oil Spill Activity Cards,** one card for each student group (see page 30)
- ☐ **Oil Spill Scenario & Presentation Guide-lines,** one set for each student group (page 31)
- ☐ **Monterey Bay National Marine Sanctuary (MBNMS) Map,** one for each student group. To obtain a free map for your classroom, please call (831) 647-4201 (see page 32)
- ☐ **Geographic Information System (GIS) Overlays*,** one set for each student group (see pages 33-41)
- ☐ Overhead projector and transparency markers for presentations
- ☐ Access to the Internet (optional)
- ☐ Paper for student journals or lab notebook
- ☐ Full-sized color poster of MBNMS (small version on page 32), available from the MBNMS office. Contact Karen Grimmer; karen.grimmer@noaa.gov, (831)647-4253

** Prepare overlays by photocopying masters onto transparencies.*

Discussion



What makes Monterey Bay National Marine Sanctuary special? Monterey Bay, the largest of NOAA's marine sanctuaries, hosts a rich array of habitats. Within its boundaries lie rugged rocky shores, lush kelp forests, and one of the deepest underwater canyons on the West Coast. The canyon cuts more than 3,500 meters (2 miles) deep and reaches nearly 100 kilometers (60 miles) out to sea. Sanctuary habitats abound with life, from tiny plankton to huge blue whales. With its great diversity of habitats and life, the sanctuary is a national focus for marine research and education programs.

Habitats:

Sandy beaches	Submarine canyon
Rocky shores	Pelagic, open ocean
Kelp forests	Wetlands

Key Species:

Sea otter	Brown pelican
Gray whale	Rockfish
Market squid	Giant kelp

Cultural Resources:
Indian midden sites
Naval airship USS *Macon*

Latitude and Longitude: 36° N 122° W

Web Site Address:
http://www.mbnms.nos.noaa.gov

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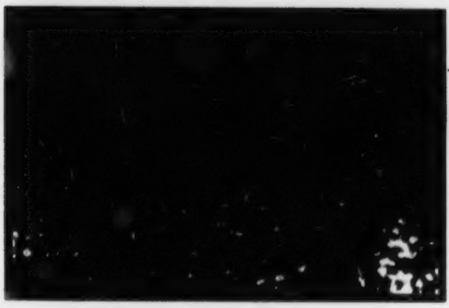


Procedure:

Part 1: Using the MBNMS Map for an Investigation

1 Using the poster-size MBNMS map, as a class, look at the scale and color bars in the bottom left corner. Identify which colors are urban areas (gray), ocean (light and dark blue depending on depth), low-lying croplands and coastal wetlands (green).

2 Identify some of the dominant features of the map. These might include Monterey Bay, the city nearest your school, the mountain ranges (Santa Lucia, Gabilan, Santa Cruz, and Diablo Range), the undersea canyons (Soquel, Carmel, and Monterey), rivers leading to the Sanctuary (Salinas, Pajaro, and San Lorenzo), and Highways 1 and 101.

3 Discuss the use of GIS as a technological tool for creating maps and analyzing areas spatially. Using an overhead projector and transparency copies of GIS overlay sheets, briefly look at the different types of data that scientists have collected.

4 Explain that these images are created from distinct GPS (Global Positioning System) data points that are entered into a computer in units of latitude and longitude.

5 Place the GIS transparencies on top of each other to demonstrate how GIS data is considered multi-dimensional or spatial. These overlays will be the information sources that students will use during their mock public meeting presentations.

6 Discuss the importance of monitoring natural areas in order to identify if changes are due to natural or human disturbances. Please refer to **Sustainable Seas Expeditions Research** article in Unit 1 of the Teacher Resource Book (page 13).

Part 2: What Resources Might be Affected by a Major Oil Spill?

Students will represent six different community groups. (See **Oil Spill Activity Cards**)

The groups are:

1) the **Sanctuary Advisory Council**, who will preside over a public meeting. See inset **NOAA Announces $50,000 Grant!**

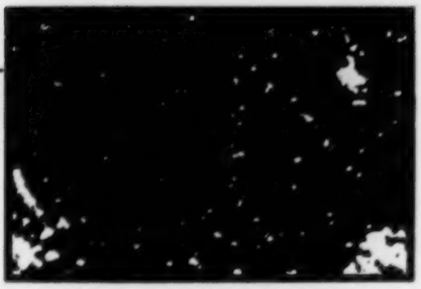
2) **US Coast Guard Officers**, who will report on the situation as they see it.

3) **Park Rangers and Oil Spill Volunteers**

4) **Scientists**

5) **Fishing Industry Representatives**

6) **Monterey Bay National Marine Sanctuary Representatives**



The last four groups will present their perspective to the Council on how to mitigate (or reduce) the negative environmental and economic impacts which might occur due to the oil spill event.

* **IMPORTANT NOTE**: There is a grant of $50,000 that will be allocated to the community for determining how to deal with the oil spill's impact.

1. Divide the class into six groups. Each group should receive one of the six **Activity Cards**, an **Oil Spill Scenario** sheet, and a **Presentation Guidelines** card. The cards will explain each group's roles and responsibilities.

2. Read the **NOAA $50,000 Grant Announcement** (see box, this page) to the class. Have each group discuss their concerns and answer the questions raised on their activity card.

3. Have each group give a five-minute presentation to the Sanctuary Advisory Council following the rules listed in the **Presentation Guidelines** handout.

NOAA ANNOUNCES $50,000 GRANT!

In response to today's environmental disaster—when 300 million liters of crude oil spilled in the Monterey Bay National Marine Sanctuary—the National Oceanic & Atmospheric Administration (NOAA) has directed $50,000 toward emergency aid.

An emergency public meeting will be held at 7:00 p.m. tonight in the town hall to consider where the funding will go and what actions the public can take to protect our coast and resources.

In order to voice your opinion on how the funding is allocated, you will need to present your case to the Monterey Bay Sanctuary Advisory Council. They will make the appropriate recommendations to NOAA.

If you are interested in speaking, please prepare a five minute presentation with supporting graphics. You may sign-up upon entry to the meeting. At the close of the meeting, the Council will announce any relevant actions and their funding recommendations.

Please join in this important effort!

OIL SPILL ACTIVITY CARDS · (ONE CARD PER GROUP)

Panel

SANCTUARY ADVISORY COUNCIL

Primary Concern: Which community groups need funding? How much? Members of this panel may include a state park official, a government official, a scientist, an educator, a business owner, a fishermen, and a diver.

Panel's Task: Listen objectively to all perspectives and recommend to NOAA how the $50,000 should be allocated. You will discuss after hearing all presentations, and then announce your decisions.

Oil Spill Response Team

U.S. COAST GUARD

Primary concern: Assess the situation and inform the public of the oil spill location, size, direction of movement, potential for damage, etc.

Answer the Questions: What area will be most immediately affected? (plot latitude & longitude) Refer to the Oil Spill Scenario sheet.

Stakeholder Group #1

PARK RANGERS & OIL SPILL VOLUNTEERS

Primary Concern: Impact of the oil spill on wildlife and sensitive habitats.

Answer the Questions: How might the spill affect marine animals and their habitat?

How much of the money, if any, should be put toward rescue and rehabilitation efforts?

Stakeholder Group #2

SCIENTISTS (U.S. Fish & Wildlife biologists)

Primary Concern: Long-term assessment of the oil spill impact on wildlife & natural areas.

Answer the Questions: How long will the environmental impacts of the spill be felt?

How would a long-term monitoring study assess these impacts? What types of monitoring techniques are recommended? (Surveys have varied costs depending if they are conducted on foot, by boat or by plane).

Stakeholder Group #3

FISHING INDUSTRY (fishermen, seafood packers & seafood markets)

Primary Concern: Impact of oil spill on fishing.

Answer the Questions: How might the oil spill affect fishing, now and in the future?

How much money might the fishing industry lose?

Can fishermen seek reimbursement from the government?

Stakeholder Group #4

SANCTUARY STAFF (resource managers, researchers & educators)

Primary Concern: Impact of oil spill on *all* Sanctuary resources. MBNMS is a multi-use area.

Answer the Questions: How can the MBNMS help coordinate all the oil spill clean-up operations? How can the MBNMS support research and monitoring efforts?

OIL SPILL SCENARIO

"On January 9th, 2000, a 350 meter cargo freighter ____________________ (your school name), was traveling in a dense fog, gale winds, and heavy seas. At 9:00 pm, the freighter collided with an oil tanker called ____________________ (another school) which was carrying 300 million liters of crude oil. The bow of the freighter was slightly damaged but was in no risk of sinking. The oil tanker, however, sustained heavy damage to its midsection. It was leaking oil into the ocean and was in danger of sinking."

The U.S. Coast Guard station in Monterey, CA received a distress signals from both ships and informed the Monterey Bay National Marine Sanctuary of the disaster. Below are the details of the situation.

Tanker Position:	Latitude:	36° 40′ N
	Longitude:	123° 10′ W
Wind Speed:	35 knots from the NW	
Sea Condition:	5 meter waves	
Vessel Damage:	Oil from both the cargo freighter and the tanker was seen on the surface. The oil tanker was definitely sinking. The freighter was dead in the water with engine room flooding and rudder damage.	

PRESENTATION GUIDELINES

ONE CARD PER GROUP

The Sanctuary Advisory Council is composed of 20 federally-appointed representatives from government agencies, local institutions, and user groups (diving, fishing, harbors, agriculture) concerned with the resources of the Monterey Bay National Marine Sanctuary. One student group will represent the council members, and will sit in the front facing the rest of the audience. Their role is to advise NOAA on issues important to the community.

Your stakeholder group must develop and present a clear and persuasive argument to the Council members. You want them to clearly understand what your needs are, and why you deserve a good portion of the $50,000 that is available. The funding is available for clean-up efforts, research and monitoring, and to help mitigate (reduce) the negative effects of the spill.

PRESENTATION RULES

- Each team will have five minutes to present its case to the Sanctuary Advisory Council (SAC).
- Your presentation should be colorful and informative and include the use of graphics such as the poster-size map and/or GIS overlays with an overhead projector.
- Look through the GIS overlays to find those of importance to your group. Explain why those particular resources are most important to your community group, and how they are or will be affected by the spill.
- At the end of each presentation, there will be an additional five minutes allotted for questions and comments from the rest of the audience who have come to participate in this public meeting.
- At the conclusion of all the presentations, the SAC will then deliberate and inform the audience of the recommendations it will provide to NOAA. NOAA will then allocate the funds accordingly.

MAP OF MONTEREY BAY NATIONAL MARINE SANCTUARY

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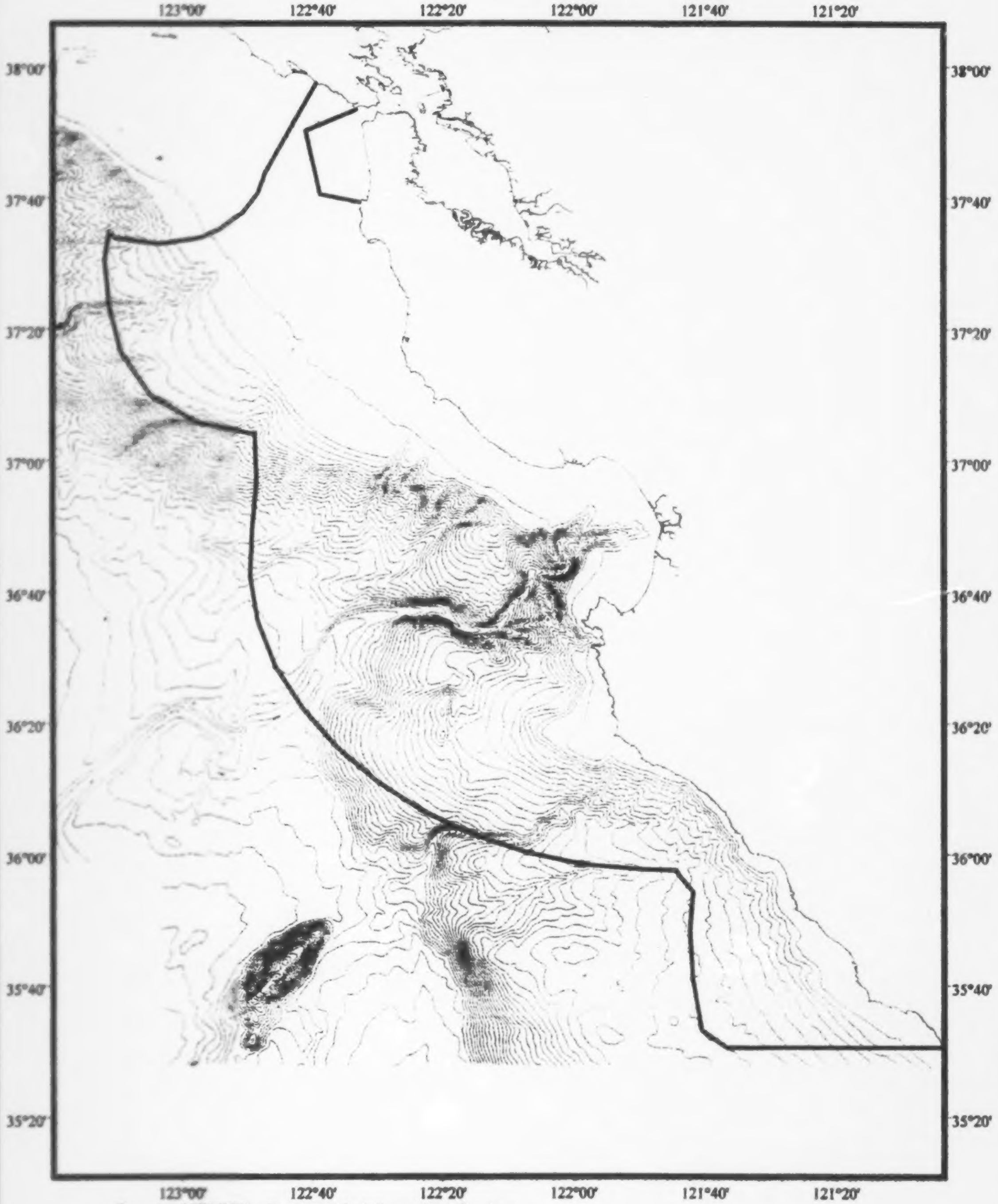
Monterey Bay National Marine Sanctuary
Coastline, Bathymetry (100m intervals), & Boundary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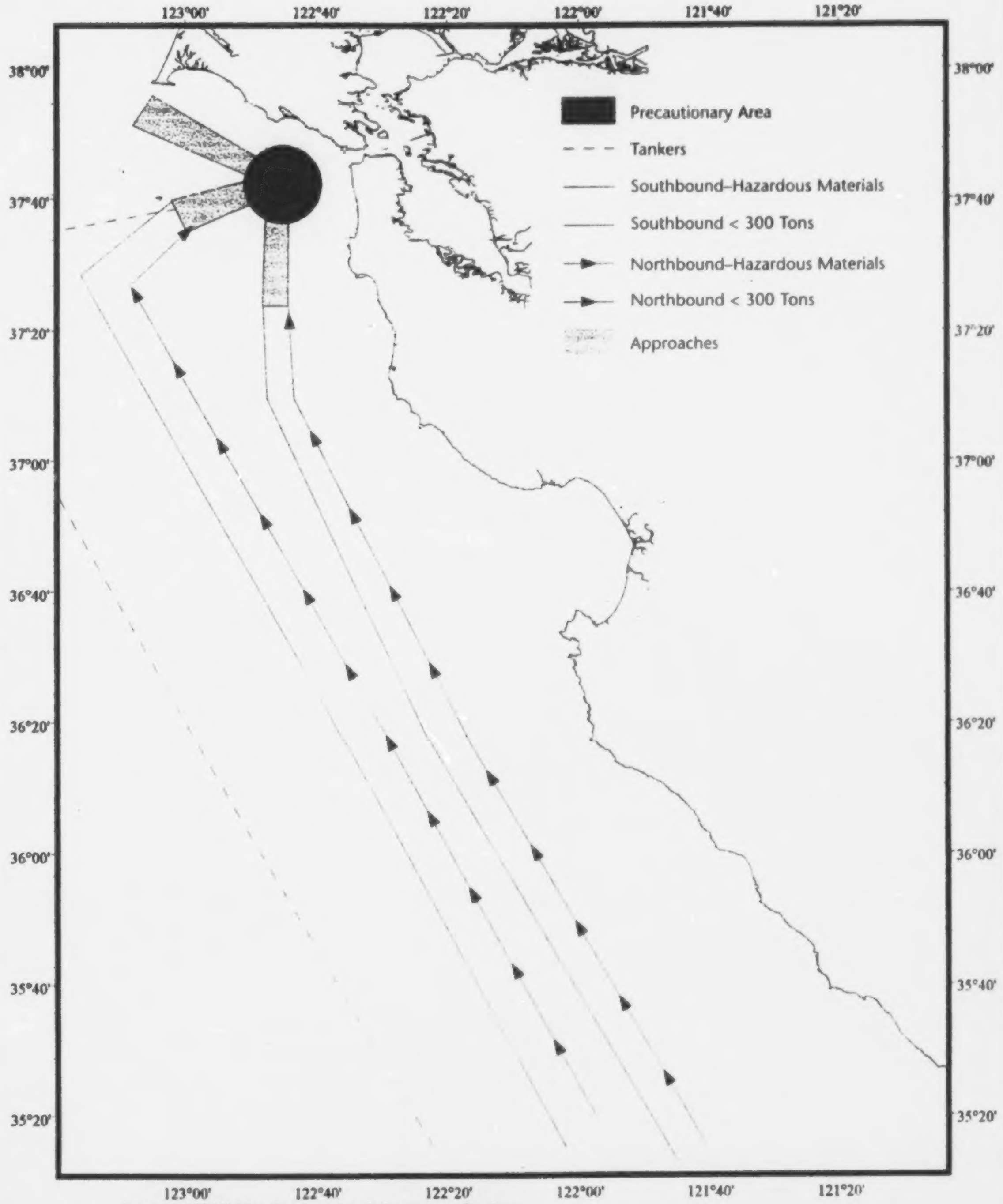
Source: MBNMS's Geographic Information System

GIS OVERLAY

Monterey Bay National Marine Sanctuary
Vessel Traffic Routes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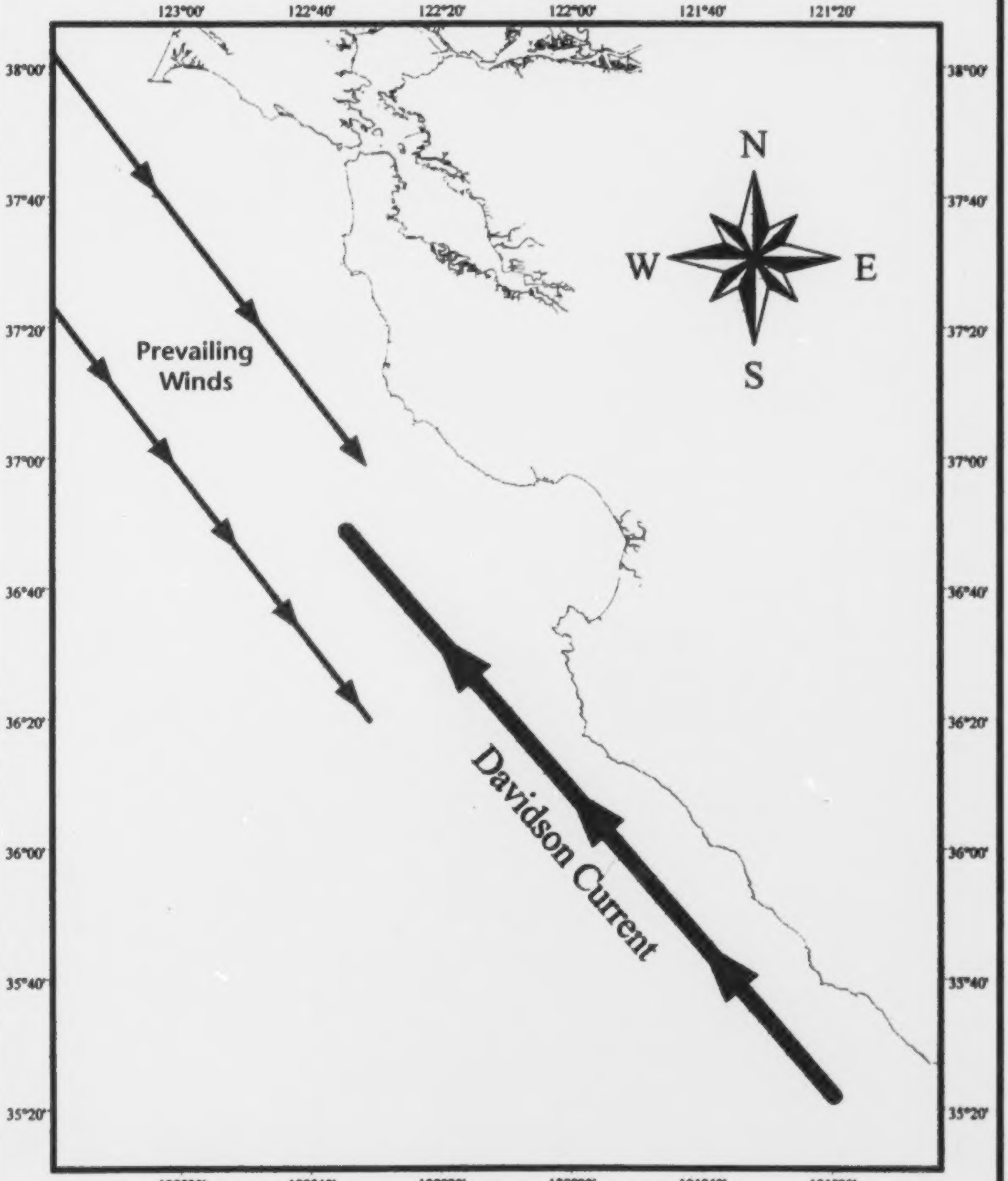
35°20'
Precautionary Area
Tankers
Southbound–Hazardous Materials
Southbound < 300 Tons
Northbound–Hazardous Materials
Northbound < 300 Tons
Approaches

Source: MBNMS's Geographic Information System

GIS OVERLAY

Monterey Bay National Marine Sanctuary
Current & Prevailing Winds - Winter



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N
W
E
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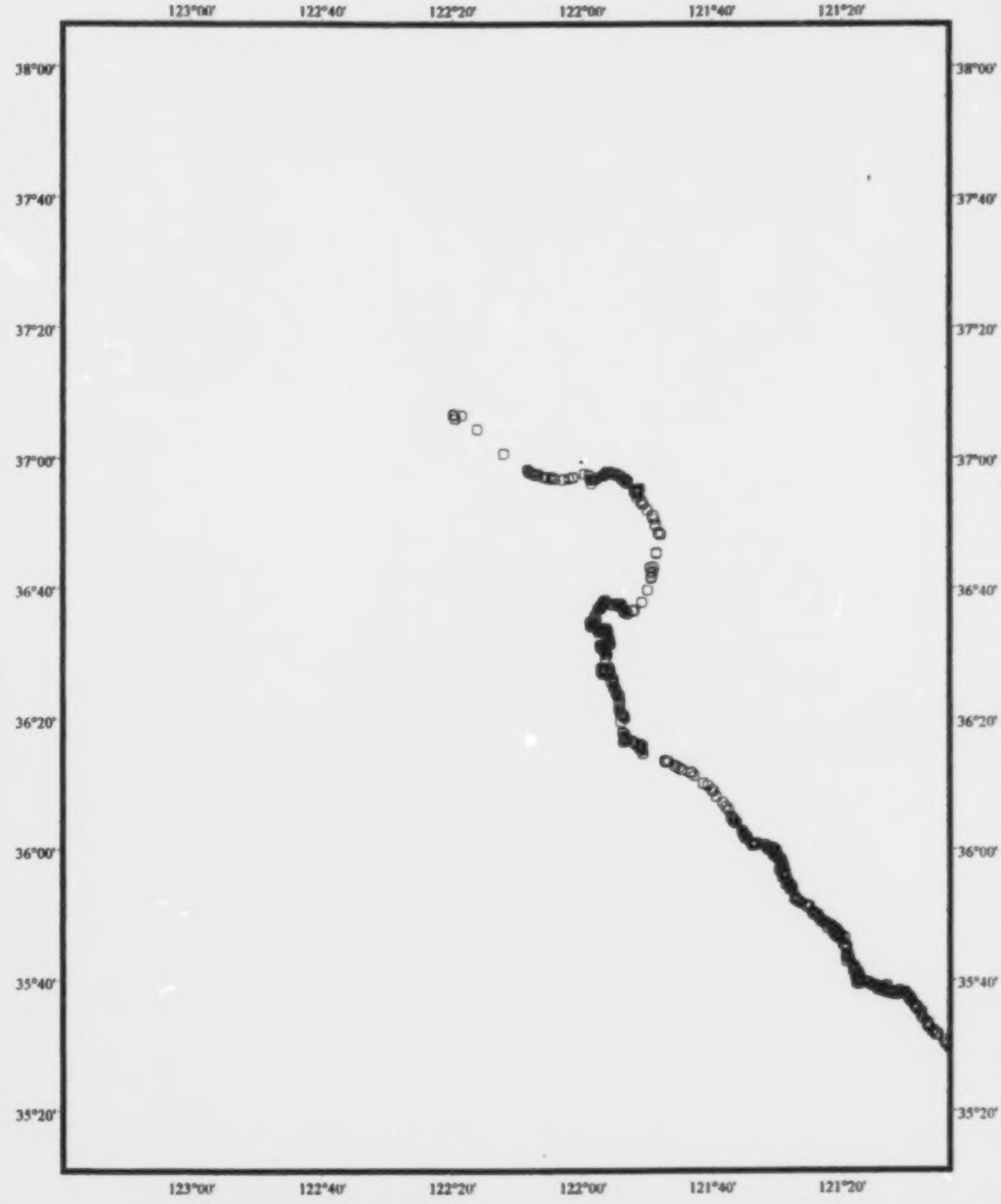
Prevailing Winds
Davidson Current

Source: MBNMS's Geographic Information System

GIS OVERLAY

Monterey Bay National Marine Sanctuary
Sea Otter Sightings, 1992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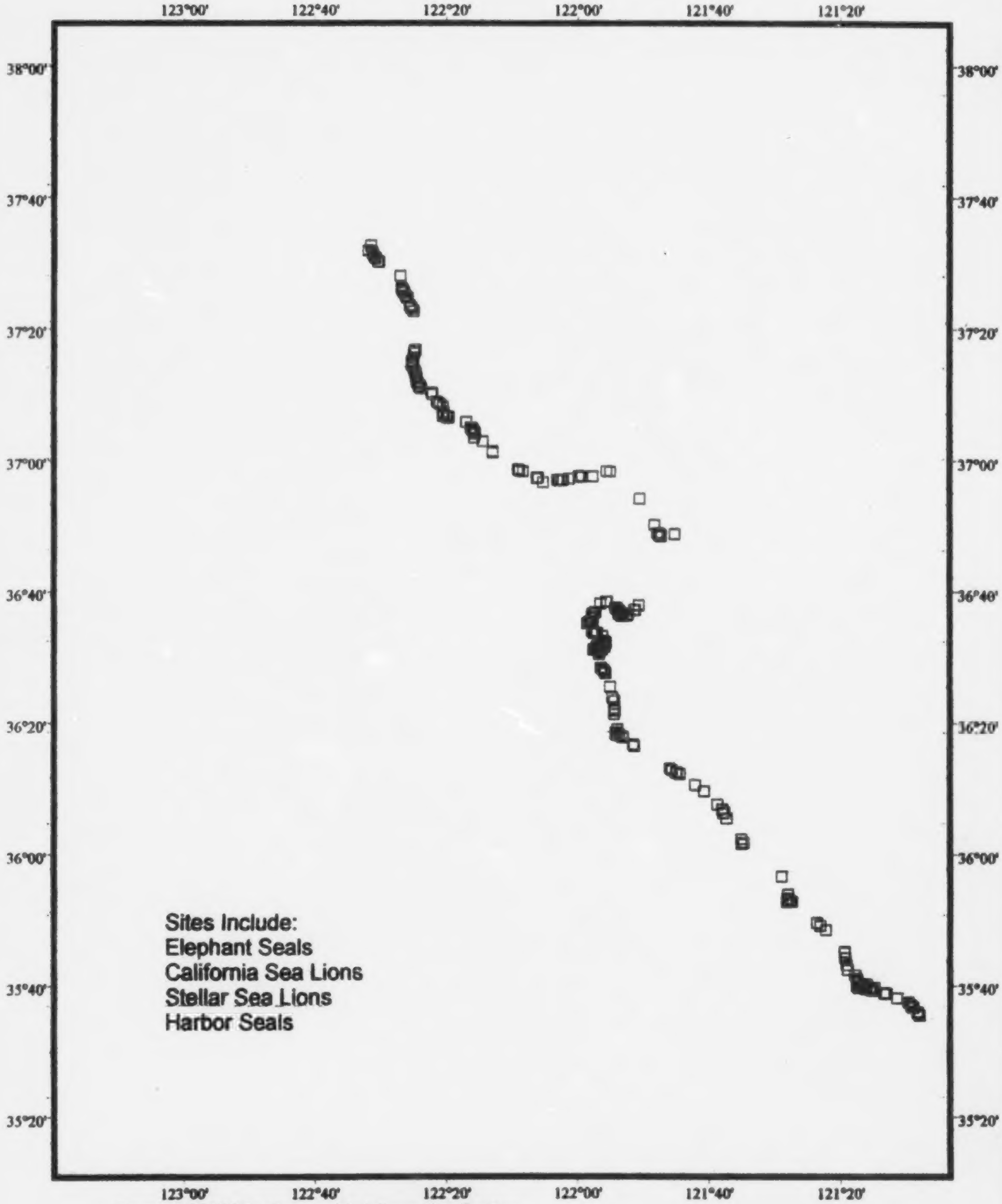
Source: MBNMS's Geographic Information System

GIS OVERLAY

Monterey Bay National Marine Sanctuary
Pinniped Haul-Out Areas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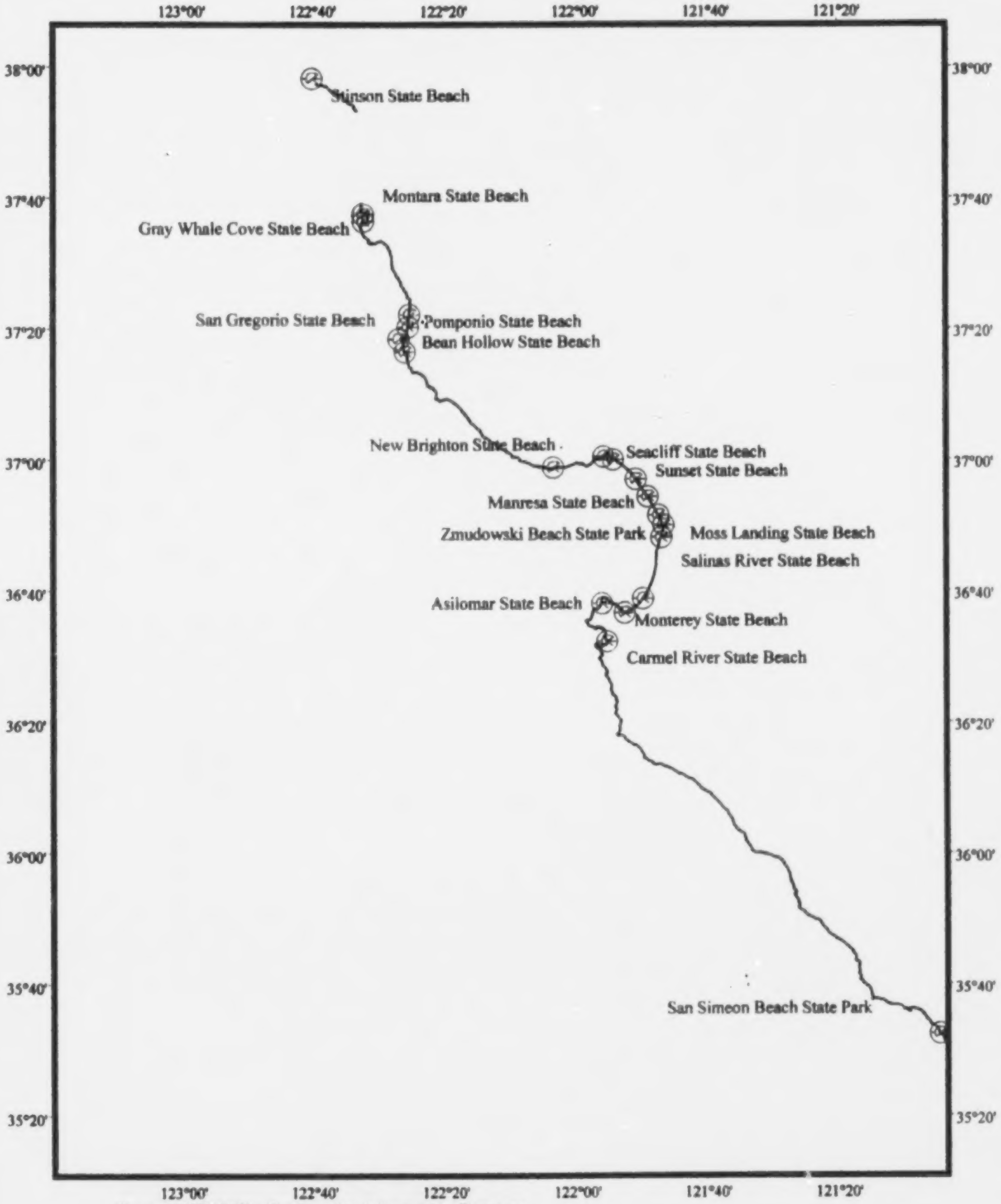
Sites Include:
Elephant Seals
California Sea Lions
Stellar Sea Lions
Harbor Seals

Source: MBNMS's Geographic Information System

Monterey Bay National Marine Sanctuary
Recreational Areas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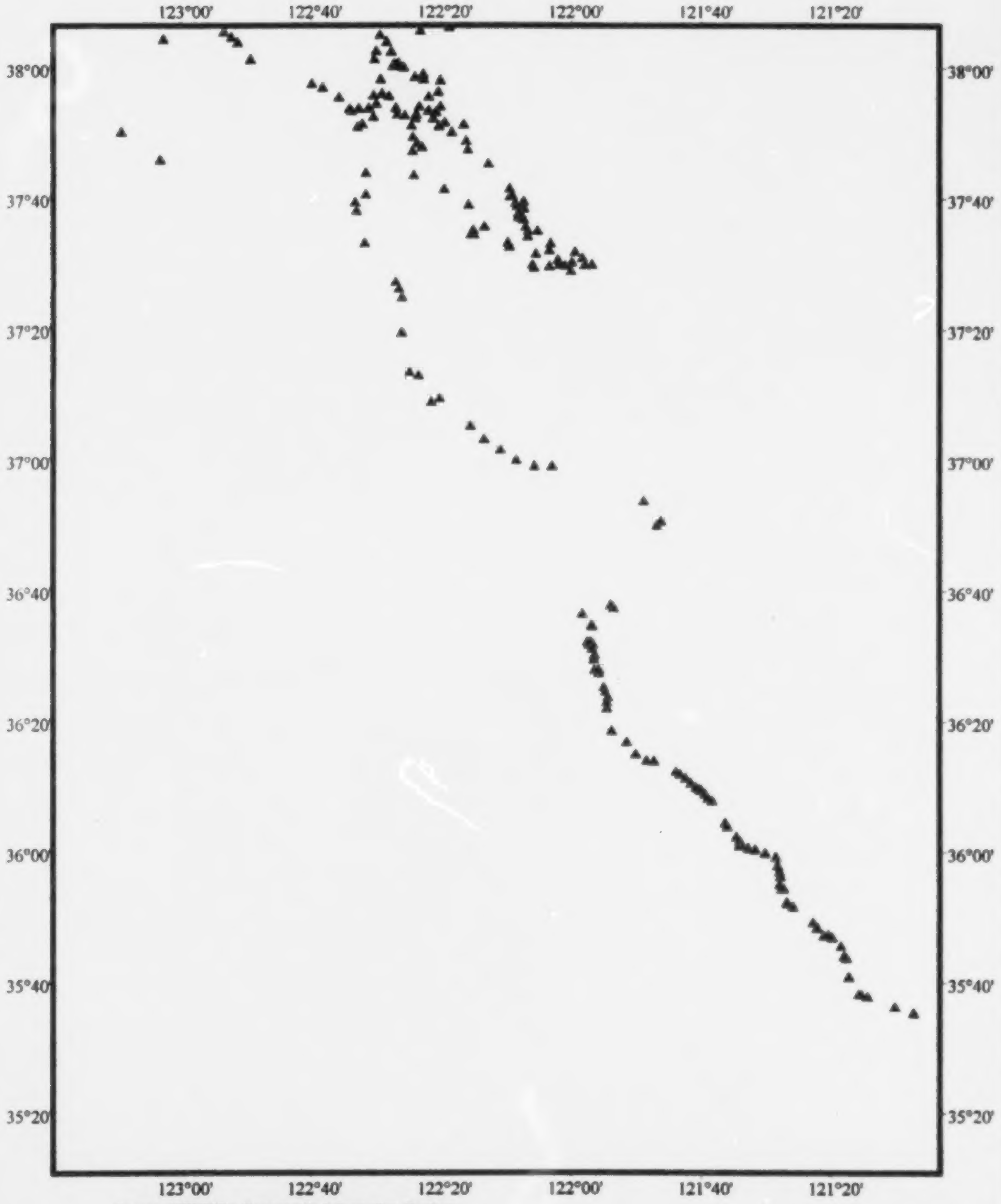
Stinson State Beach
Montara State Beach
Gray Whale Cove State Beach
San Gregorio State Beach
Pomponio State Beach
Bean Hollow State Beach
New Brighton State Beach
Seacliff State Beach
Sunset State Beach
Manresa State Beach
Zmudowski Beach State Park
Moss Landing State Beach
Salinas River State Beach
Asilomar State Beach
Monterey State Beach
Carmel River State Beach
San Simeon Beach State Park

Source: MBNMS's Geographic Information System

GIS OVERLAY

Monterey Bay National Marine Sanctuary
Seabird Nesting Areas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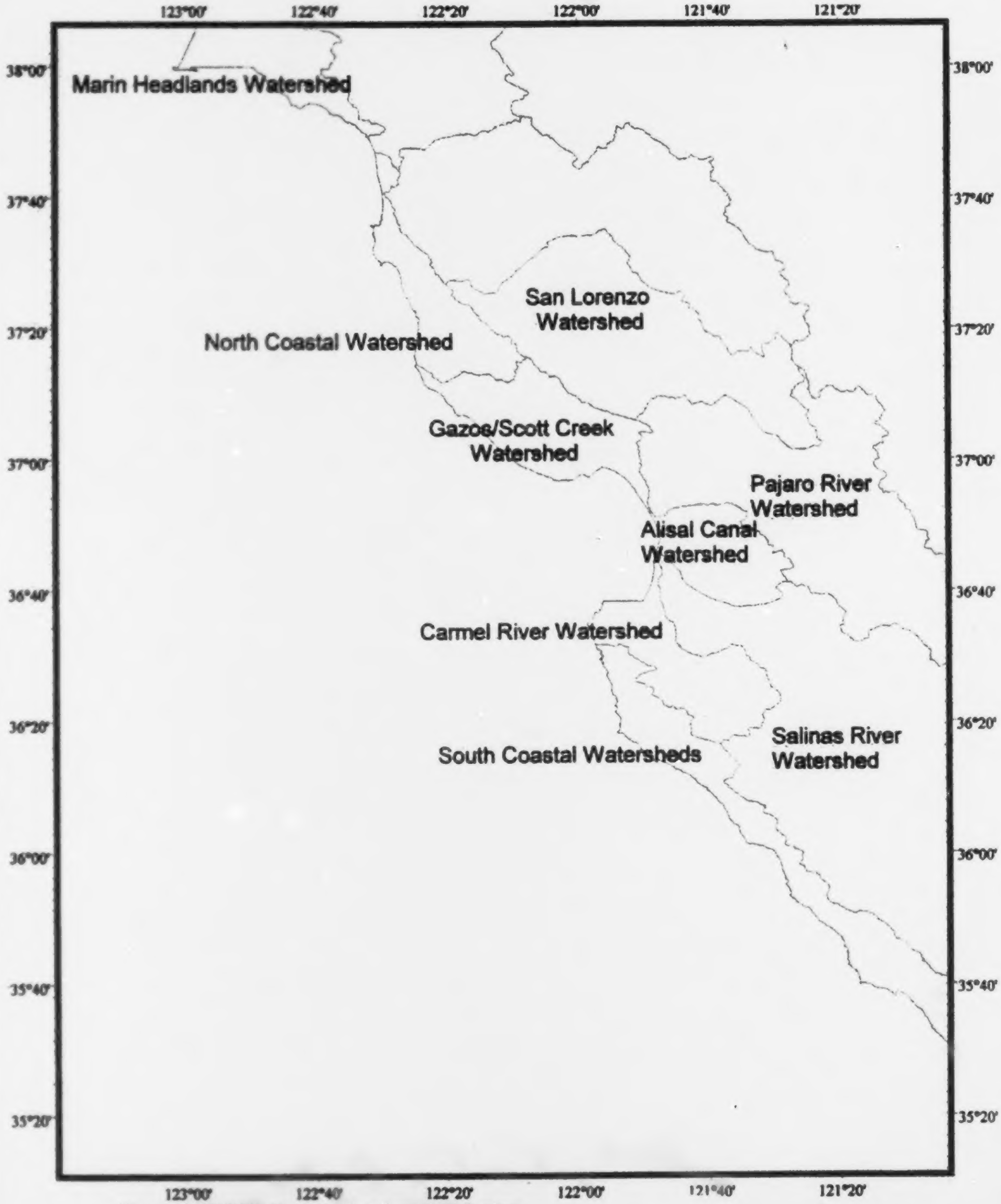
Source: MBNMS's Geographic Information System

Monterey Bay National Marine Sanctuary Coastal Watersheds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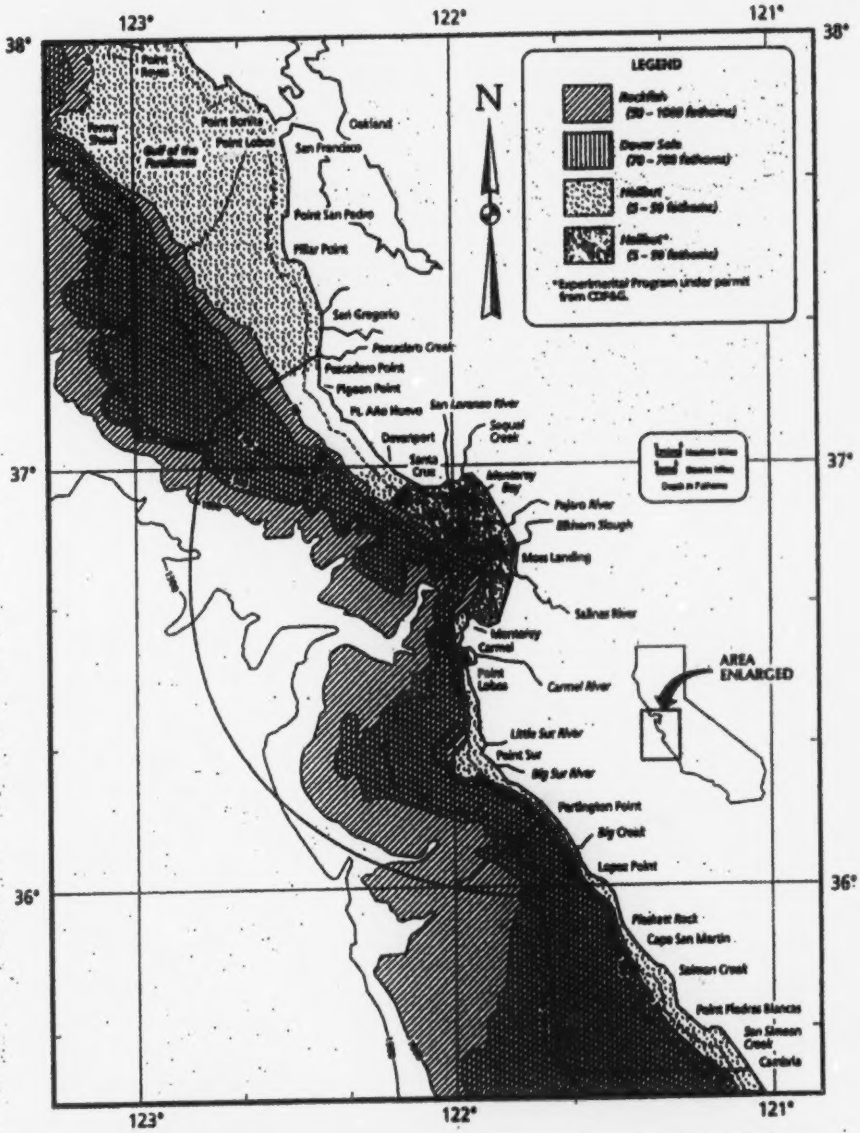
Marin Headlands Watershed
San Lorenzo Watershed
North Coastal Watershed
Gazos/Scott Creek Watershed
Pajaro River Watershed
Alisal Canal Watershed
Carmel River Watershed
Salinas River Watershed
South Coastal Watersheds

Source: MBNMS's Geographic Information System

Monterey Bay National Marine Sanctuary
Trawl Fishery Areas


123°
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36°
LEGEND
Rockfish (50 – 1000 fathoms)
Dover Sole (70 – 700 fathoms)
Halibut (5 – 30 fathoms)
Halibut* (5 – 30 fathoms)
*Experimental Program under permit from CDF&G.
N
Point Reyes
Gulf of the Farallones
Point Bonita
Point Lobos
Oakland
San Francisco
Point San Pedro
Pillar Point
San Gregorio
Pescadero Creek
Pescadero Point
Pigeon Point
Pt. Año Nuevo
San Lorenzo River
Soquel Creek
Davenport
Santa Cruz
Monterey Bay
Pajaro River
Elkhorn Slough
Moss Landing
Salinas River
Monterey
Carmel
Point Lobos
Carmel River
Little Sur River
Point Sur
Big Sur River
Partington Point
Big Creek
Lopez Point
Plaskett Rock
Cape San Martin
Salmon Creek
Point Piedras Blancas
San Simeon Creek
Cambria
AREA ENLARGED

Figure 15. Trawl Fishery. *Atlas of Marine Resources for Central California, Central Coast Regional Studies Program, August 1990.*

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Loggerhead Sea Turtle

Gray's Reef National Marine Sanctuary

INVESTIGATION 6

Sea Turtle Lifecycles

In this investigation, students learn about the life cyles of sea turtles and how conservation efforts for these animals rely on understanding their migration patterns. In the first activity, students will be playing the role of a research scientist and will be expected to think critically about sea turtle conservation. Some of the questions they will be asked have more than one answer; others remain unanswered. Students will also graph and interpret real turtle migration data. In the second activity, students will look at the nesting habits of loggerhead sea turtles on Georgia's Barrier Islands and the potential problems that are created when humans interact with nature.

ACTIVITIES

Mapping Sea Turtle Migrations

Sea Turtle Nesting on the Georgia Barrier Islands

LEARNING OBJECTIVES

Students will:

- Investigate the migration patterns of sea turtles;
- Learn about various methods for tracking sea turtles;
- Investigate the problems a sea turtle may encounter when nesting near areas of human habitation;
- Apply their conclusions to sea turtle conservation efforts.

STANDARDS

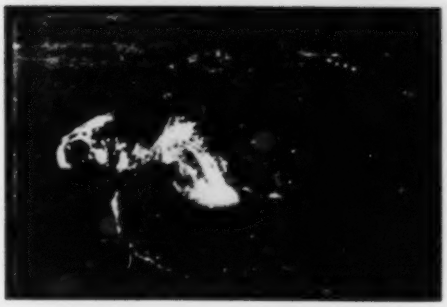
Geography Standard 1
How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

Geography Standard 14
How human actions modify the physical environment

Science Education Standards
Developing self-directed learners

Developing an understanding of populations and ecosystems

Developing abilities necessary to do scientific inquiry



ACTIVITY Mapping Sea Turtle Migrations

Guiding Question

What types of technologies are used for tracking sea turtle migrations, and how is migration data interpreted?

Discussion

Gray's Reef National Marine Sanctuary is one of the largest nearshore live bottom reefs found in the South Atlantic Bight. As such, it is an important habitat for sea turtles including the threatened loggerhead, *Caretta caretta*. The ledges and overhangs of the reef provide the loggerhead sea turtle with protected resting spots, a bountiful resource of food, and close proximity to nesting sites on barrier island beaches.

Although observations by sanctuary staff have documented the presence of loggerhead sea turtles within the sanctuary and along the Georgia Bight, little is known about their daily and seasonal behavior, or about their use of different ocean habitats. Many studies have focused on nesting behavior and post nesting movement of adult females, while little work has been conducted on offshore turtles, especially males and juveniles. Management plans that include the protection of this species are limited by a small amount of data.

Materials

- ☐ **Mapping Sea Turtle Migration Background** handouts (three pages per student, see pages 45-47)
- ☐ **Mapping Sea Turtle Migration Question** handout (three pages per student, see pages 48-50)
- ☐ **Turtle Migration Sample Data Sheet and Map** (one per student, see page 51)
- ☐ **Turtle Migration Data Sheet** and **Map** (there are 7 sets of data with corresponding maps, each student gets one set, see pages 52-63)
- ☐ **National Marine Sanctuary Map** (see Unit 1, page 6)
- ☐ North American Map or Globe
- ☐ Pencil

Procedures

1 Have students read the **Mapping Sea Turtle Migration Background** handout.

2 Have students study the **Migration Data Sheet and Map** of their turtle. Have them label the major oceans and land masses on their map. They may need to compare their map with a larger map of North America to determine what portion of the U.S. or Mexico coast they are reading.

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3 Have students number each satellite transmission in their data table. To the left of the first transmission (earliest date), write "1"; to the left of the second transmission (date), write "2"; and so on until they have numbered each transmission listed in their data table.

4 Have students graph the location of each satellite transmission and record the transmission number on their map.

5 Have students connect the numbers sequentially to show the path of their sea turtle. Students are tracing migration routes of different sea turtles. Have them compare their map with their classmates.

6 When they have completed their maps, have students answer the questions on the **Mapping Sea Turtle Migration Question** handout.

Extension Activities

Have students use the Internet to find other sea turtles that are being tracked using satellite tags. Data from several different tracking projects can be found at either of the following web sites:
Caribbean Conservation Corporation
(http://www.cccturtle.org/sat1.htm)
or WhaleNet (http://whale.wheelock.edu/whalenet-stuff/stop_cover.html)

Have students determine the distance and speed their turtle traveled using an online distance generator. Determine the average daily distance and total distance traveled.
http://www.indo.com/distance/

Have students download dive information from WhaleNet's Satellite Tag Data Archive. Determine the average length and depth for loggerhead sea turtle dives.
http://whale.wheelock.edu/whalenet-stuff/stop_cover.html

Credits

Adapted from information and data provided by:

Caribbean Conservation Corporation
(http://www.cccturtle.org/)

and

WhaleNet/Loggerhead Turtle Data
WhaleNet (http://whale.wheelock.edu/whalenet-stuff/stop_cover.html)

MAPPING SEA TURTLE MIGRATION BACKGROUND (page 1 of 3)

Introduction:

Sea turtles have survived for millions of years and have changed very little during this time. Now their future is uncertain. All seven species of sea turtles are listed as either endangered or threatened species. Worldwide conservation efforts have focused predominately upon protecting sea turtles on their nesting beaches. Much of what we know about sea turtles has resulted from these efforts, however, sea turtles spend very little of their life on land. Females return to land only to nest, while males never come to shore. In order to fully protect sea turtles, we need to understand their life cycles and protect these animals across their entire range. Current scientific efforts seek to learn more about sea turtles by tagging them and gaining insights into their ranges, behavior, and ecology.

Migration

Beginning as hatchlings (baby sea turtles just hatched from eggs), sea turtles migrate throughout their lives. Hatchlings swim from the beach to the open ocean. In the Atlantic and Caribbean, loggerhead hatchlings make their way into the Gulf Stream. Amidst the floating *Sargassum* weeds (a type of marine algae), the hatchlings find safety, ample food, and few predators. They spend several years drifting passively. Scientists believe that loggerhead turtles follow the currents and travel completely around the Atlantic ocean basin at least once. Older juveniles return to live and feed near shore. Adult females migrate to a new feeding area after reaching sexual maturity. They stay in this new habitat, except during breeding season. When it is time to mate and nest, females leave their feeding grounds, and travel hundreds to thousands of kilometers, returning to their natal (birth) beaches to nest. Little is known about the behavior of adult male sea turtles.

Navigation

In the open ocean, there are no visible landmarks and sea turtles encounter strong ocean currents. Turtles have modest vision and can raise their heads out of the water only a few centimeters. Even with these limitations, sea turtles swim long distances and return to their natal (birth) beaches to reproduce. Researchers are currently trying to understand how they are able to navigate, and although several hypotheses exist, they are still being tested.

Sustainable Seas Expeditions

Studying Migration

The migratory nature of sea turtles creates many challenges for those trying to protect them. In order to fully protect them, we need to know where sea turtle habitats are located, how turtles behave in their different habitats, and the routes they use to migrate between them. Yet, most of a sea turtle's life is spent at sea, where direct observation is difficult. New technologies, such as satellite telemetry, allow scientists to monitor sea turtles throughout their range.

Thousands of sea turtles from around the world have been tagged to help collect information about growth rates, reproductive cycles, and migration routes. After decades of study, much has been learned; however, many questions remain unanswered.

Tagging Methods

Flipper Tags: One of the simplest tagging methods involves placing a small, harmless metal tag on one of the turtle's flippers when it comes ashore to nest. Each tag includes a coded number and a message asking people to return the tag if it is found. When people return the tag, they get a small reward and are asked a few questions about the turtle. Sometimes scientists find sea turtles that are missing their flipper tags, and suspect that the metal tags may resemble a fishing lure that attracts fishes that pick at it.

Imbedded Tags: Scientists have also begun painlessly inserting a small needle-like tag under the skin of the sea turtle's flippers. The imbedded tags do not stick out and are not visible externally, so are unlikely to be accidentally removed. Researchers use a hand-held scanner to check the flippers for imbedded tags and to read the identification code.

Satellite Telemetry: Researchers have recently begun using satellites to track sea turtles in the open ocean. A hand-held radio-sized transmitter is attached to the back of an adult or juvenile sea turtle. The transmitter is glued directly to the turtle's carapace (shell) behind its head. It has a small flexible antenna, which can break the surface and transmit when the turtle comes up to breathe. A passing satellite receives the information and sends it back to researchers on Earth. After 8-10 months, the transmitter stops working and safely falls off the turtle. Sometimes, a transmitter may quit transmitting early. Satellite tags are also much more expensive than the flipper or imbedded tags.

MAPPING SEA TURTLE MIGRATION BACKGROUND (page 3 of 3)

Data from Space

Scientists receive the transmitted data as a series of numbers, beginning with the tag, or ID number for the turtle. They also receive information on the date, time, and location of the turtle's transmission, as well as the fix quality, which measures the reliability of the data. Some satellite transmitters also collect information on the length, depth (average and maximum), and number of dives the turtle performs in a given period of time.

Data from a sample tag is provided below.

Date (dd.mm.yy)	Time (hr:min:sec)	LC (fix quality)	Latitude	Longitude
Days and months are each reported with two digits. The first would be represented as "01".	Time is reported according to Greenwich Mean Time on a 24 hour clock.	LC stands for the Location Class. Classes of 0 and up are the best because the data is derived from 4 or more messages. Higher numbers represent more accurate readings. Letters represent less accurate readings.	The positioning data is received as a decimal equivalent of a degree. Obtain minutes by multiplying the decimal portion by 60. Latitude is measured north or south of the equator.	Longitude is measured east or west of the Prime Meridian at Greenwich, England.
22.08.96	23:06:55	LC 0	Lat1: 48.275N	Lon1:69.232W
Aug 22, 1996	11:06:55 pm	good	48°16′ N	69°14′ W

Using the information provided by the satellite tags and either computer-based or manual graphing programs, researchers are able to track the movement of individual sea turtles. The information they collect provides insight into the life cycle and ecology of sea turtles. Depending upon how much detail their maps have, scientists can learn about the types of habitats and prey items that sea turtles prefer. Scientists hope to use this information to better understand and protect sea turtles.

Information and additional satellite tracking data are available on the Internet from the Caribbean Conservation Corporation (CCC) and WhaleNet web sites. Data from current and past years are available for various regions of the country along with satellite tracking data for other marine species.

MAPPING SEA TURTLE MIGRATION QUESTIONS (page 1 of 3)

1) Scientists estimate that only one out of 1,000 hatchlings survives to reproduce. Describe five hazards a baby sea turtle must overcome in order to reach adulthood. Hazards may be encountered either on shore or in the water. After listing your obstacles, classify the hazard as natural or human-influenced.

Hazards:

a) d)

b) e)

c)

2) How do sea turtles migrate long distances without depending upon their eyesight? Suggest other environmental clues to which they might be responding.

3) Why do scientists want to know the location of sea turtle habitats and their migration routes?

4) What are the advantages/disadvantages of each type of tracking device?

Method	Advantage	Disadvantage
Flipper tag		
Imbedded tag		
Satellite telemetry		

5) Most of the turtles outfitted with satellite telemetry have been female. Suggest a reason why.

168.

MAPPING SEA TURTLE MIGRATION QUESTIONS (page 2 of 3)

6) Use the information provided in the **Mapping Sea Turtle Migration Background** to interpret the following satellite data and complete the table below.

Tag #	Date	Time	LC	Latitude	Longitude
02113	15.02.99 ________	13:58:22 ________	1 ____	31.112N ________	80.619 W ________
02114	19.03.99 ________	________ 7:34:05 am	1 ____	________ 30° 55′ N	80.655W ________
02115	________ Jun 16, 1999	09:21:25 ________	3 ____	31.165N ________	________ 80° 43′ W

7) Which sea turtle do you have? Where is it found? What ocean is s/he found in?

8) Are there any repeated days or "holes" (missing days) in your data table? List an example of each of these.

Transmissions for turtle ___ began on __________ and ended on _________.

No information was received from my turtle on ________________________.

Multiple transmissions were received from my turtle on _________________.

9) How long was your sea turtle tracked? Did the transmissions end prematurely (less than 8- 10 months)? Suggest three possible reasons why the transmission could have ended.

10) Describe the migration route for your turtle. Include beginning and ending positions (latitude and longitude), an indication of time, as well as a narrative description (ex. Humpty Dumpty was released on September 28, 1998 at 31.864°N and 80.949°W. Humpty traveled north towards North Carolina until ...).

MAPPING SEA TURTLE MIGRATION QUESTIONS (page 3 of 3)

11) Does the migration pattern make sense in terms of the behavior of the sea turtle?

12) Look at the **Map of the National Marine Sanctuaries** provided by your teacher. Does your turtle travel near or through any of the marine sanctuaries? If so, which one(s)?

13) Why are international treaties necessary to protect pelagic (open ocean) species such as sea turtles?

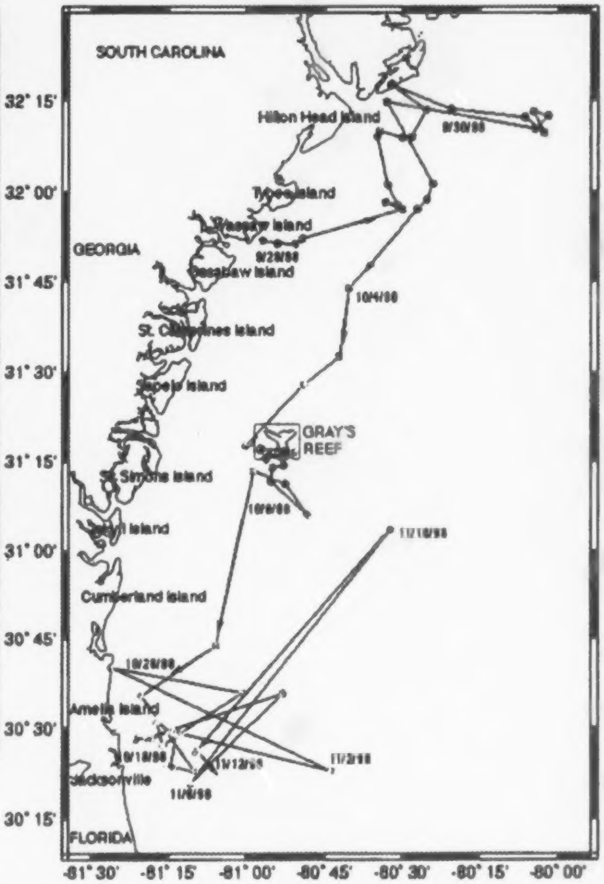
14) What role do national marine sanctuaries play in protecting all marine organisms?

15) In three to four sentences, summarize what you have learned about satellite tracking programs and their importance to conservation efforts.

TURTLE MIGRATION SAMPLE DATA SHEET AND MAP

Humpty Dumpty, a juvenile loggerhead sea turtle, was captured in Gray's Reef National Marine Sanctuary as part of a sea turtle tagging project. When NOAA personnel hoisted Humpty aboard their vessel in order to attach the transmitter, they noticed that Humpty had a cracked shell. Humpty Dumpty was rehabilitated at Marineland, Florida. Two months later, Humpty was released at Gray's Reef. The sex of the turtle was not determined.

	Date	Latitude	Longitude
1.	9/28/98	31.864N	80.949W
2.	10/1/98	32.204N	80.107W
3.	10/7/98	31.440N	81.775W
4.	10/15/98	30.395N	81.242W
5.	10/20/98	30.481N	81.228W
6.	10/29/98	30.598N	81.013W
7.	11/8/98	30.555N	81.322W
8.	11/14/98	30.470N	81.130W
9.	11/23/98	30.511N	81.128W
10.	11/30/98	30.459N	81.219W
11.	12/2/98	30.513N	81.245W
12.	12/7/98	30.560N	81.451W
13.	12/17/98	30.614N	81.456W
14.	12/24/98	30.422N	81.234W
15.	12/28/98	29.632N	80.923W
16.	1/3/99	30.121N	81.102W
17.	1/9/99	30.087N	80.800W
18.	1/15/99	30.178N	81.007W
19.	1/22/99	30.830N	80.370W
20.	1/29/99	30.735N	80.937W
21.	2/8/99	30.944N	80.805W
22.	2/14/99	31.131N	81.186W
23.	2/21/99	31.037N	80.763W
24.	3/1/99	30.872N	80.771W
25.	3/9/99	30.809N	80.801W
26.	3/16/99	30.902N	80.660W
27.	3/21/99	30.930N	80.833W
28.	3/28/99	30.952N	80.689W
29.	4/5/99	31.134N	81.102W
30.	4/10/99	31.115N	80.701W


SOUTH CAROLINA
Hilton Head Island
9/30/98
Tybee Island
Wassaw Island
9/28/98
GEORGIA
Ossabaw Island
10/4/98
St. Catherines Island
Sapelo Island
GRAY'S REEF
St. Simons Island
10/8/98
Jekyll Island
11/18/98
Cumberland Island
10/28/98
Amelia Island
10/18/98
11/12/98
11/2/98
Jacksonville
11/6/98
FLORIDA
32° 15'
32° 00'
31° 45'
31° 30'
31° 15'
31° 00'
30° 45'
30° 30'
30° 15'
-81° 30'
-81° 15'
-81° 00'
-80° 45'
-80° 30'
-80° 15'
-80° 00'

BEST COPY AVAILABLE

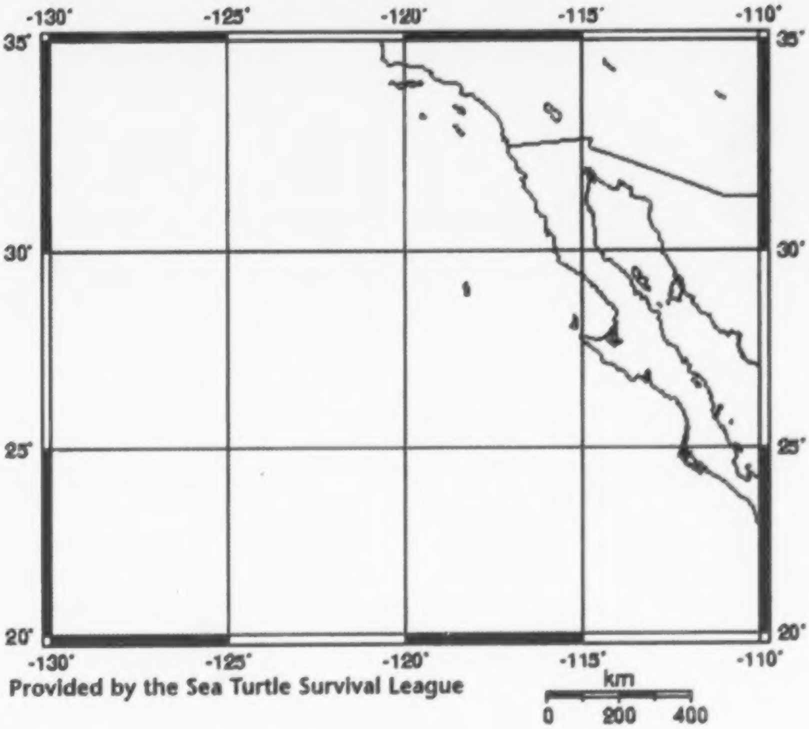
TURTLE #1 MIGRATION DATA

Lupita is a sub-adult, female loggerhead sea turtle. She weighs 158 lbs. and was released near Santa Rosalita, Baja California (Mexico) during the summer of 1998. This turtle is truly in the ocean wilderness and probably only rarely encounters a fishing boat. She is being monitored by the Sea Turtles of the Pacific tagging project.

Satellite Positions for Lupita 7/3/98 – 9/19/98

Date	Latitude	Longitude
7/3/98	28.646 N	114.243 W
7/5/98	28.829 N	114.529 W
7/8/98	28.778 N	115.601 W
7/11/98	27.809 N	116.596 W
7/11/98	27.606 N	116.891 W
7/11/98	27.508 N	117.489 W
7/17/98	27.994 N	118.206 W
7/20/98	27.521 N	118.627 W
7/23/98	27.393 N	119.136 W
7/26/98	27.246 N	119.845 W
7/26/98	27.184 N	120.028 W
7/29/98	26.912 N	120.563 W
8/1/98	26.552 N	121.041 W
8/4/98	26.395 N	121.310 W
8/10/98	25.768 N	121.514 W
8/13/98	25.619 N	121.481 W
8/16/98	25.428 N	121.380 W
8/19/98	25.148 N	121.403 W
8/22/98	24.357 N	121.681 W
8/31/98	23.922 N	123.082 W
9/3/98	23.638 N	123.315 W
9/6/98	23.380 N	123.795 W
9/12/98	22.681 N	124.655 W
9/15/98	22.406 N	124.823 W
9/19/98	22.072 N	125.160 W

Map for Lupita


-130°
-125°
-120°
-115°
-110°
35°
30°
25°
20°
km
0
200
400

Provided by the Sea Turtle Survival League

TURTLE #2 MIGRATION DATA

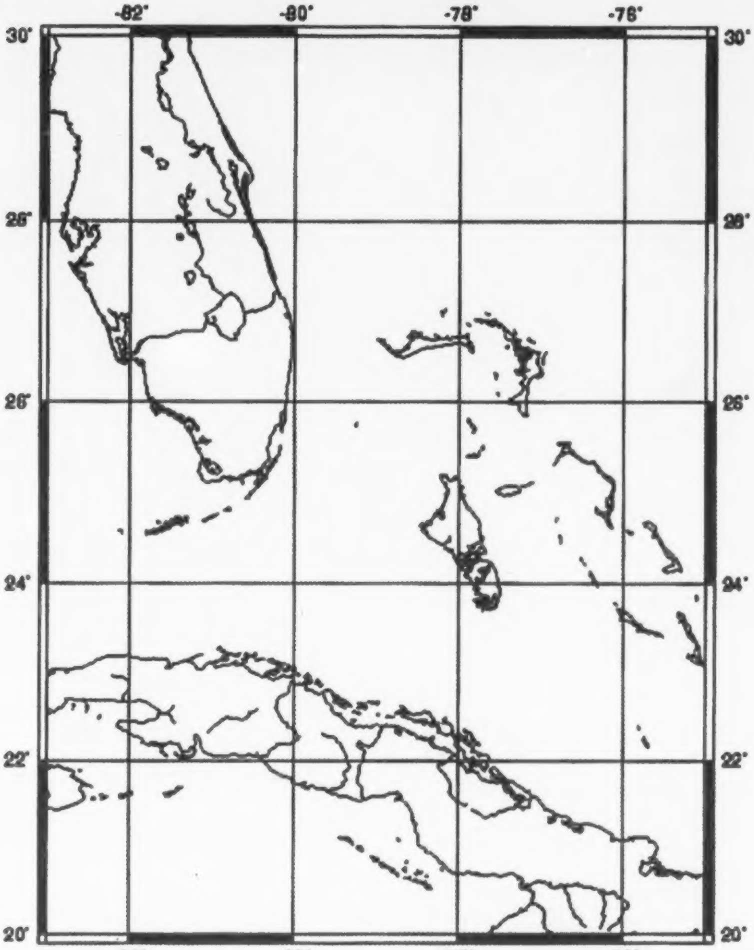
Scarlet was first encountered nesting on June 5th, 1998 at the Archie Carr National Wildlife Refuge in Brevard County, Florida. She was observed nesting again on August 11th, and a satellite tag was attached when she finished nesting.

Satellite Positions for Scarlet 8/11/98 – 3/14/98

Date	Latitude	Longitude
8/11/98	28.018 N	80.533 W
8/13	28.089 N	80.065 W
8/14	27.692 N	80.302 W
8/17	27.178 N	79.962 W
8/19	27.188 N	80.041 W
8/21	26.976 N	79.985 W
8/22	27.386 N	79.688 W
8/23	27.958 N	79.521 W
8/23	28.215 N	79.335 W
8/25	27.791 N	78.635 W
8/26	27.567 N	78.271 W
8/27	27.316 N	78.118 W
8/28	27.166 N	78.114 W
8/29	26.908 N	78.273 W
8/30	26.898 N	78.657 W
8/31	26.874 N	78.818 W
9/1	26.686 N	78.979 W
9/2	26.546 N	78.850 W
9/3	25.752 N	78.706 W
9/4	25.386 N	78.893 W
9/5	25.233 N	79.003 W
9/6	24.753 N	79.072 W
9/7	24.195 N	79.105 W
9/8	23.980 N	79.102 W
9/9	23.616 N	78.855 W
9/10	23.318 N	78.568 W
9/11	23.063 N	78.117 W
9/12	22.922 N	77.930 W
9/13	22.721 N	77.518 W
9/14	22.693 N	77.761 W
9/15	22.567 N	77.517 W
9/17	22.785 N	77.280 W
9/20	22.782 N	77.062 W
9/23	22.757 N	77.146 W
10/14	22.796 N	77.121 W
10/16	22.832 N	77.165 W
11/5	22.666 N	77.591 W
11/20	22.655 N	77.502 W
12/15	22.589 N	77.610 W
1/18/99	22.624 N	77.612 W
3/14	22.573 N	77.510 W

TURTLE #2 MIGRATION MAP

Map for Scarlet


-82°
-80°
-78°
-76°
30°
28°
26°
24°
22°
20°

Provided by the Sea Turtle Survival League

km
0 50 100

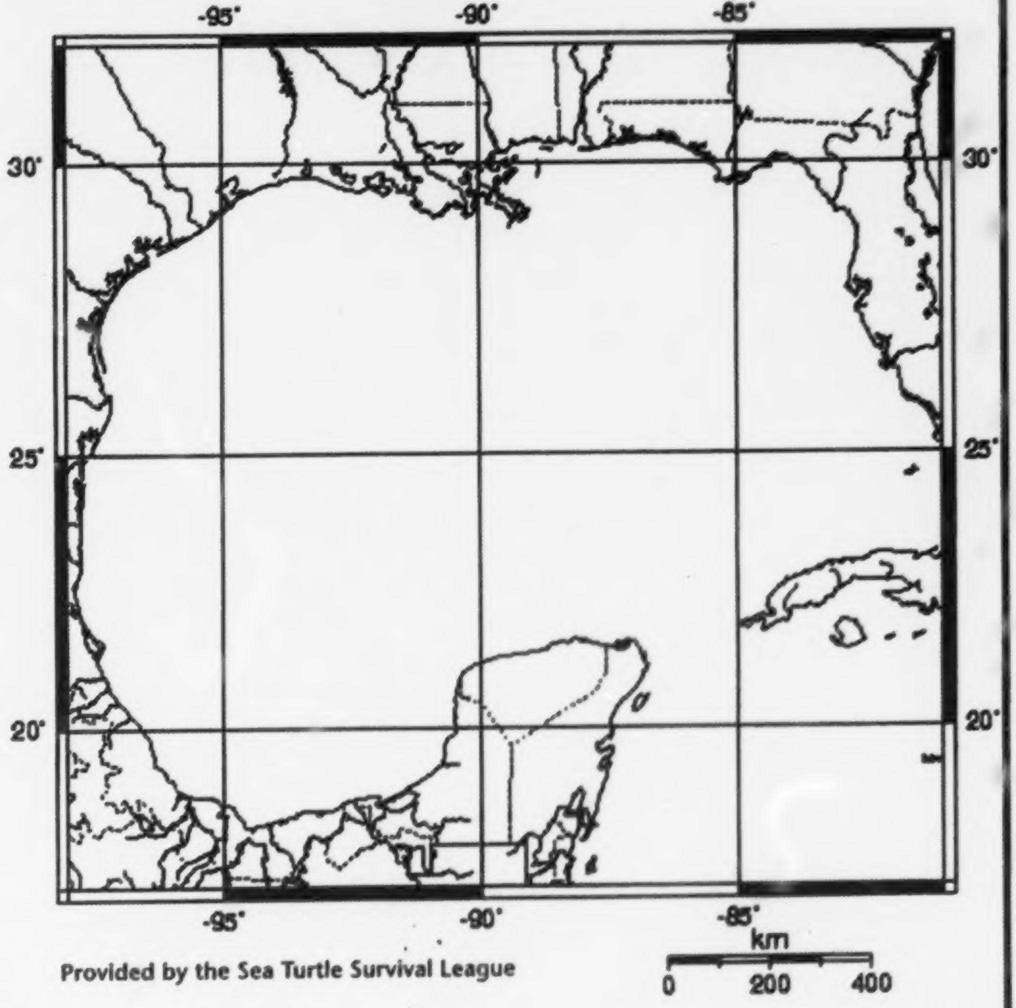
TURTLE #3 MIGRATION DATA

Sarah was first tagged on July 26th, 1998 when she was discovered nesting on Manasota Key, FL. She was again encountered nesting on August 5th on Manasota Key, but at the northern end of the island. A satellite tag was applied when she finished nesting. Sarah measured 91.4 cm in carapace (shell) length.

Satellite Positions for Sarah
8/6/98 to 3/17/99

Date	Latitude	Longitude
8/6/98	27.050 N	82.438 W
8/6	26.999 N	82.654 W
8/7	26.886 N	82.903 W
8/10	26.611 N	83.277 W
8/12	26.316 N	83.874 W
8/13	25.384 N	84.169 W
8/14	24.462 N	84.126 W
8/15	23.343 N	83.644 W
8/15	22.992 N	83.576 W
8/17	22.746 N	84.016 W
8/18	22.560 N	84.353 W
8/19	22.281 N	84.690 W
8/21	21.840 N	85.023 W
8/21	21.597 N	85.138 W
8/22	21.374 N	85.337 W
8/23	21.315 N	85.561 W
8/24	21.400 N	85.867 W
8/24	21.652 N	86.059 W
8/26	22.494 N	86.634 W
8/27	22.186 N	86.900 W
8/28	22.210 N	87.627 W
8/29	22.333 N	87.884 W
8/30	22.591 N	87.789 W
9/11	22.612 N	87.933 W
9/23	22.602 N	87.965 W
10/13	22.614 N	87.956 W
11/7	22.631 N	87.862 W
11/21	22.680 N	87.992 W
12/16	22.621 N	87.903 W
1/18/99	22.612 N	87.874 W
3/17	22.627 N	87.877 W

Map for Sarah


-95°
-90°
-85°
30°
25°
20°
km
0
200
400

Provided by the Sea Turtle Survival League

TURTLE #4 MIGRATION DATA SHEET

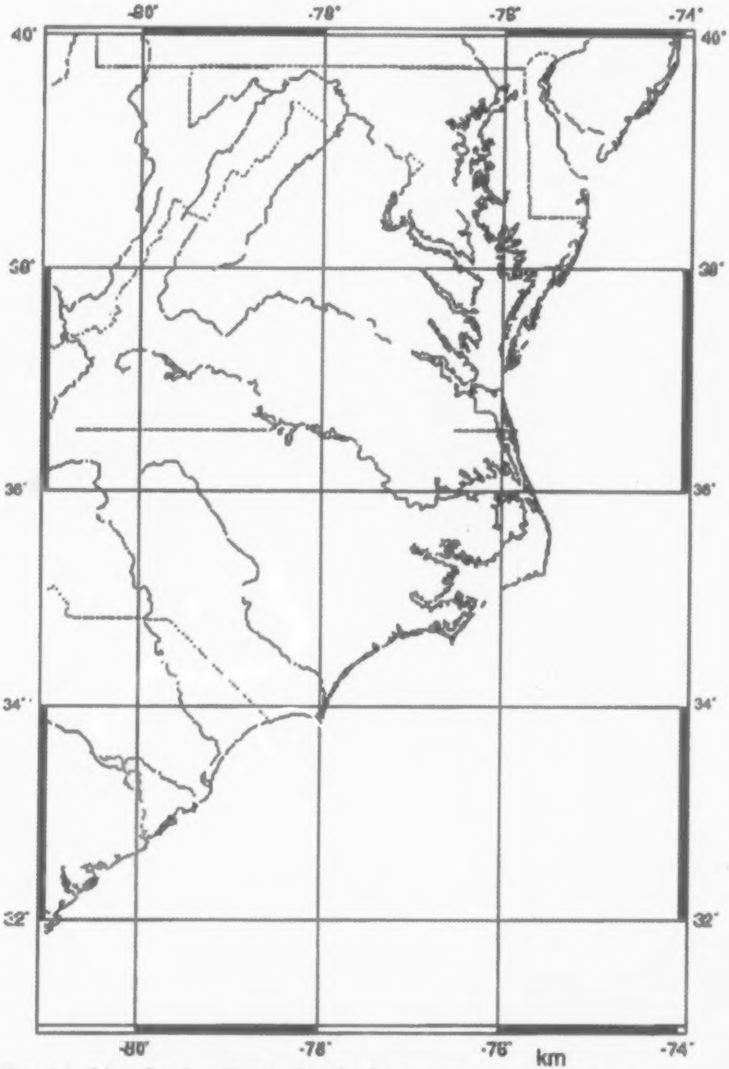
Virginia was tagged during a non-nesting siting near Cape Island. She remained in the area for two weeks and probably laid another clutch. Virginia spent her time during Hurricane Bonnie, east of Norfolk, VA. She measured 99 cm in carapace (shell) length.

Satellite Positions for Virginia
7/14/98 - 3/3/99

Date	Latitude	Longitude
7/14/98	33.157 N	79.375 W
7/23	33.013 N	79.653 W
7/28	32.934 N	78.653 W
7/30	33.241 N	78.065 W
8/1	33.795 N	77.760 W
8/2	33.851 N	77.173 W
8/10	35.360 N	75.314 W
8/11	35.494 N	75.235 W
8/13	35.836 N	75.245 W
8/20	36.602 N	75.245 W
8/25	36.906 N	75.088 W
8/31	36.270 N	75.114 W
9/22	36.625 N	75.160 W
9/27	36.545 N	75.199 W
10/5	36.581 N	75.159 W
10/12	36.460 N	75.164 W
10/19	36.628 N	75.156 W
10/25	36.521 N	75.125 W
10/31	36.479 N	75.083 W
11/3	36.170 N	75.346 W
11/4	36.098 N	75.450 W
11/5	35.961 N	75.451 W
11/5	35.890 N	75.482W
11/8	35.092 N	75.519 W
11/15	34.523 N	76.259 W
11/23	33.450 N	77.103 W
11/24	33.205 N	77.450 W
11/25	33.010 N	77.729 W
11/27	32.959 N	78.056W
11/28	32.701 N	78.461 W
11/29	32.699 N	78.552 W
11/30	32.506 N	78.814 W
12/3	32.085 N	79.311 W
12/6	31.611 N	79.620 W
12/11	31.529 N	79.737 W
12/12	31.529 N	79.687 W
1/3/99	31.525 N	79.682 W
1/11	31.667 N	79.607 W
1/17	31.889 N	79.377 W
1/23	32.010 N	79.349 W
2/15	31.843 N	79.398 W
2/21	31.679 N	79.710 W
3/3	32.052 N	79.434 W

TURTLE #4 MIGRATION MAP

Map for Virginia


-80°
-78°
-76°
-74°
40°
38°
36°
34°
32°
-80°
-78°
-76°
-74°
km
0
50
100

Provided by the Sea Turtle Survival League

TURTLE #5 MIGRATION DATA

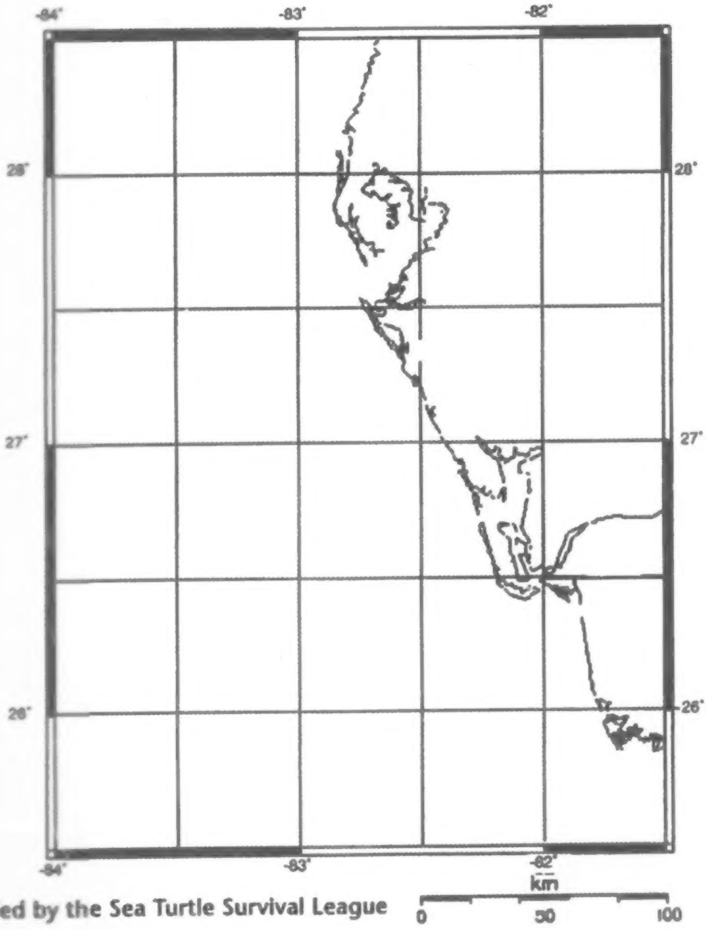
Joe is an adult male loggerhead sea turtle. He was captured and released May 31, 1998 off Egmont Key in Tampa Bay, FL. Joe's carapace length was 99.3 cm, and he weighed 84.4 kg (230 lbs.). Joe is one of the largest loggerhead sea turtles captured to date.

Satellite Positions for Joe
5/31/98 - 6/12/98

Date	Latitude	Longitude
5/31/98	27.462 N	83.448 W
6/01/98	27.322 N	82.815 W
6/06/98	28.148 N	82.035 W
6/07/98	28.691 N	82.162 W
6/07/98	28.103 N	82.894 W
6/08/98	28.418 N	82.904 W
6/08/98	28.641 N	83.175 W
6/09/98	28.365 N	83.495 W
6/09/98	28.519 N	82.612 W
6/12/98	28.461 N	82.891 W
6/12/98	28.446 N	82.883 W
6/12/98	28.582 N	82.903 W

TURTLE #5 MIGRATION MAP

Map for Joe


-84°
-83°
-82°
28°
27°
26°
km
0
50
100

Provided by the Sea Turtle Survival League

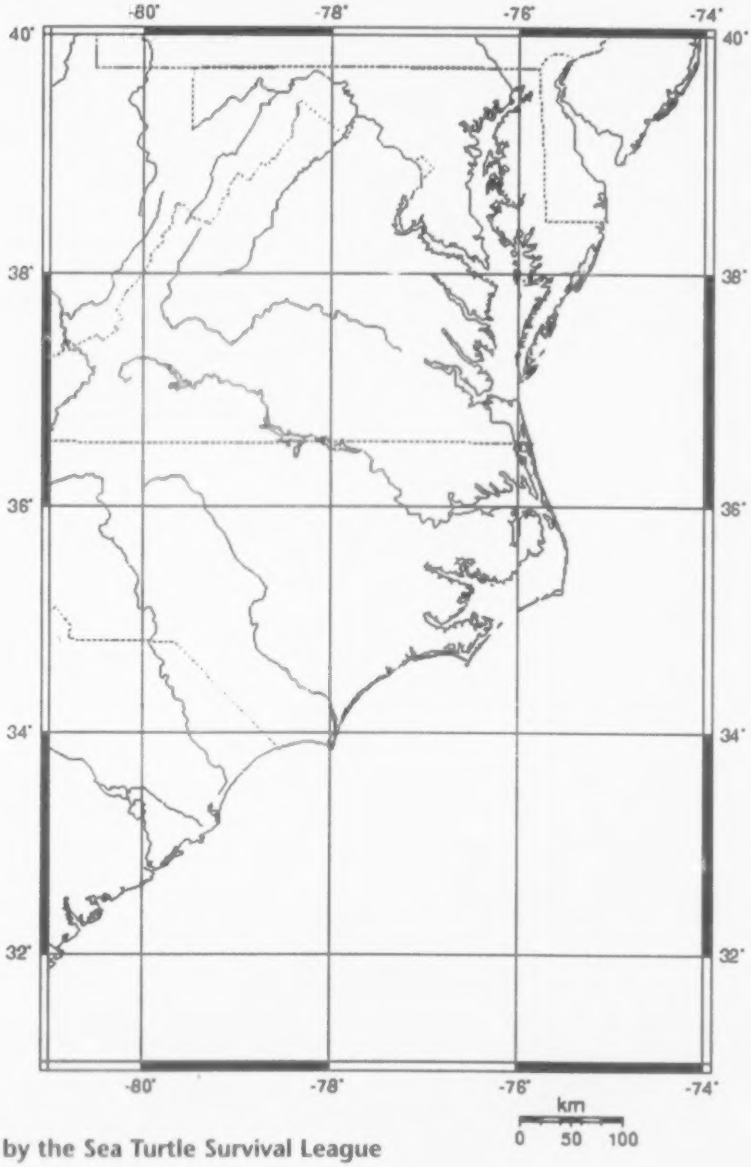
TURTLE #6 MIGRATION DATA

Jackie was satellite tagged after she nested. She had two large, deep prop cuts on the rear of her carapace, but they were old and healed over. She also had a very large pill barnacle on the top of her head. She measured 99 cm long and remained near Cape Island for two weeks. She probably laid another clutch.

Satellite Positions for Jackie
7/14/98 - 3/27/99

Date	Latitude	Longitude
7/14	33.157 N	79.375 W
7/15	33.023 N	79.374 W
7/27	32.849 N	79.374 W
7/29	32.459 N	79.561 W
8/2	31.404 N	80.521 W
8/2	31.353 N	80.536 W
8/2	31.262 N	80.576 W
8/5	29.822 N	80.873 W
8/9	28.323 N	80.285 W
8/11	27.887 N	80.087 W
8/30	27.602 N	80.087 W
9/11	27.567 N	80.112 W
9/21	27.568 N	80.069 W
9/25	27.562 N	80.108 W
10/5	27.571 N	80.142 W
10/11	27.559 N	80.086 W
10/16	27.555 N	80.083 W
10/25	27.540 N	80.109 W
10/31	27.557 N	80.264 W
11/2	27.585 N	80.122 W
11/15	27.562 N	80.065 W
11/23	27.578 N	79.927 W
11/29	27.554 N	79.991 W
12/6	27.564 N	80.074 W
12/12	27.565 N	80.088 W
1/2/99	27.560 N	80.082 W
1/8	27.566 N	80.123 W
1/29	27.582 N	80.069 W
2/15	27.557 N	80.081 W
2/23	27.545 N	80.094 W
2/28	27.607 N	80.072 W
3/9	27.574 N	80.062 W
3/14	27.563 N	80.072 W
3/21	27.545 N	80.097 W
3/27	27.561 N	80.099 W

Map for Jackie


-80°
-78°
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km
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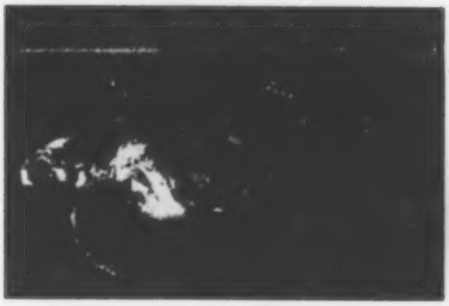
Provided by the Sea Turtle Survival League



ACTIVITY

Sea Turtle Nesting on the Georgia Barrier Islands

Guiding Question

How do human activities and management decisions impact sea turtle nesting sites?

Discussion

Gray's Reef National Marine Sanctuary protects a portion of the offshore reef system used by sea turtles. Gray's Reef is located 31.5 kilometers off the coast of Sapelo Island, one of Georgia's protected barrier islands. Gray's Reef covers 44 square kilometers of open ocean. Nesting females use this area to rest in relative security between nesting events. Juveniles spend much time here feeding on a variety of reef residents—jellies, sea nettles, and crabs of all kinds. Males may spend time here, but little is known as it is difficult to tag and track male sea turtles. After the nesting season, females will stay near the reef to feed; mating may also occur at this time.

Materials

☐ **Turtle Nesting Background** handout (one page per student, see page 66)

☐ **Turtle Nesting Questions** handout (two pages per student, see pages 67 and 68)

☐ **Map of Georgia Barrier Islands** (one page per student, see page 69)

☐ **Turtle Nesting Data Sheet** handout (one page per student, see page 70)

☐ Set of colored pencils

Procedure

1 Give each student copies of the **Turtle Nesting Background** handout, **Turtle Nesting Questions** handout, **Turtle Nesting Data Sheet** handout and **Map of the Georgia Barrier Islands**.

2 Have students read the **Turtle Nesting Background** sheet.

3 Have students answer the questions on the **Turtle Nesting Questions** handout using the map and data handouts. Tell them they will need to think through these questions and some of them will have more than one answer. Some will not have a direct answer, as many questions are currently being investigated by scientists. Have them provide evidence to support their answers.

Extension Activities

Tell students that a new island has formed between Sapelo and Little St. Simons, and they have been hired to give their "expert" opinions as to the best management plan for this new island. Four different groups are interested in managing the island. Within three years, there are 39 sea turtle nests along a two kilometer beach. Have the students look at the interested groups and come up with a management plan for the island. You may wish to modify the scenario to fit your part of the country and your local politics.

Group 1 wants to use the island as a hunting club with private membership and limited access. They would like to add hogs and deer to the island for hunting purposes.

Group 2 wants the island to be part of the Georgia State Park system with camping facilities and a ferry landing.

Group 3 is made up of wealthy land developers. This group wants a causeway constructed and exclusive housing units built along the beachfront with an outlet mall on the river side.

Group 4 is the National Oceanic and Atmospheric Administration (NOAA). They believe this would be an ideal site for another National Marine Sanctuary.

Have each group present their management plans to the rest of the class.

Prior to class, place four to six (depending on the number of student groups you will use) sheets of poster paper on the floor. Draw an island shape over all of the sheets. This represents a "big" island with many user groups!

Divide the students into groups of four or five. Give each group one sheet of the poster board that has a section of island drawn on it. Direct the groups that they have inherited this part of the island. They can do as they see fit with their section of island as long as it is legal in the United States. Give them 10 to 15 minutes to "develop" their islands. At the end of the allotted time, have each group give a presentation as to how their part of the island is to be used. As the groups present, hang the "islands" on the wall or bulletin board. Now have them "manage" the island with all the various user groups.

Have students go through the Bridge July 2000 data tip of the month on sea turtle nesting and hatching.
http://www.vims.edu/bridge/archive0700.html

Credits

Dodd, Mark G. and MacKinnon, A. H. 1999. *Loggerhead Turtle (Caretta caretta) Nesting in Georgia, 1999: Implications for Management.*

Unpublished lecture by Mike Frick, *Caretta* Project/Wassaw Island National Wildlife Refuge, given on March 27, 2000 for the Student Ocean Council at Gray's Reef National Marine Sanctuary.

en, Margaret. *Sapelo Island: Georgia's Coastal Treasure.* Sponsored by Georgia Department of Natural Resources, Sapelo Island National Estuarine Research Reserve and the National Oceanic and Atmospheric Administration.

Unpublished lecture by Susan Qashu, ranger. Cumberland Island National Seashore, November 1999 for classes at Camden County High School, Kingsland, Georgia.

TURTLE NESTING BACKGROUND

The Georgia coast is protected by a chain of 18 barrier islands. Each island varies in size and shape but all of them protect mainland Georgia from wind, waves, and storm surges. Between 75–95% of all marine species in this area depend upon these barrier islands and their vast estuary systems during some point of their life cycle. Female loggerhead sea turtles (*Caretta caretta*) return to these barrier islands from mid-May to August to lay eggs. They will lay up to four nests in one summer, each approximately two weeks apart. Between nesting efforts, many of the females will rest in the offshore shale reef system. Female turtles find secure nesting spots in crevices within the reef structure of Gray's Reef National Marine Sanctuary. Females do not eat during the nesting seasons; they nest every other year, and must eat sufficient quantities of food during non-nesting years to replace lost body mass and regain strength.

Sea turtles encounter many obstacles while nesting, including loss of habitat and predation. The demand for beach front accommodation is growing rapidly. Many people want to vacation with a beautiful view of the ocean and they do not want to travel long distances with beach chairs, coolers, toys and radios to reach the water's edge. Increased human visitation to beaches is taking a heavy toll on the nesting habitat of the sea turtles. Another human impact is the building of sea walls, groins, and jetties along the shore to create more land. These structures impede the natural shifting of sand and impact turtle nesting areas. In the end, nature will run its course resulting in greater erosion than before.

Another problem encountered by sea turtles as people migrate to the shore, is the increased amount of lighting near the beach. Artificial light provides security for people but can be a death sentence to young hatchlings as they emerge from their nest. Instinct leads hatchlings to the brightest spot on the horizon. For millions of years, the moon reflecting off the ocean has been the brightest light. Lights of "civilization" confuse the hatchlings, leading them toward busy streets, homes, or parking lots instead of to the safety of the ocean. This artificial lighting can be a deterrent during nesting as well. The female may abort a nesting attempt unless she has successfully dug the egg chamber. With extra lighting, the female may notice nearby movements that she may not have seen otherwise, and return to the sea without laying her eggs. Females that are unable to find suitable nesting habitat, or are discouraged from nesting, may release eggs into the ocean. These eggs will never hatch, causing further population decline.

A delicate balance exists between nature and recreation on the barrier islands. Humans have a desire to use these areas for pleasure and recreation, however, the natural inhabitants need these areas to ensure that their species will continue for future generations. We have the responsibility to protect these areas for the benefit of all inhabitants.

TURTLE NESTING QUESTIONS (page 1 of 2)

1) Look at the map of the Georgia Coast. Gray's Reef National Marine Sanctuary is 17 nautical miles from Sapelo Island. How many statute (land) miles offshore is Gray's Reef NMS? (1 nautical mile = 1.15 statute miles) ________ Why do you think this area was designated a national marine sanctuary?

2) Using the scale at the bottom of the map, draw a bell at the site of Gray's Reef National Marine Sanctuary.

3) Draw roads connecting the following islands with the mainland:

a. Jekyll	c. Tybee
b. St. Simons	d. Sea

4) Draw a boat near each of the following islands to show ferry access for the public:

a. Cumberland b. Sapelo

5) Color each island by the type of management:

Yellow: Private Blue: Federal Red: State

6) Identify six islands with the greatest number of nests. List them in order from the greatest number to the least number of nests.

a.	d.
b.	e.
c.	f.

7) Calculate the nesting density for these 6 islands and label it on your map. (Nesting density = # of nests/length of beach.) Now list them from the greatest density to the least density. How do these two lists compare? Are there any correlations between the type of ownership of the island and the nesting density on the island?

TURTLE NESTING QUESTIONS (page 2 of 2)

8) Of the islands with the greatest number of nests, name the ones which are privately held. How does the number of nests on these islands compare to other privately held islands that have lower nesting rates? Give three reasons that these islands might have more nests that other privately held islands.

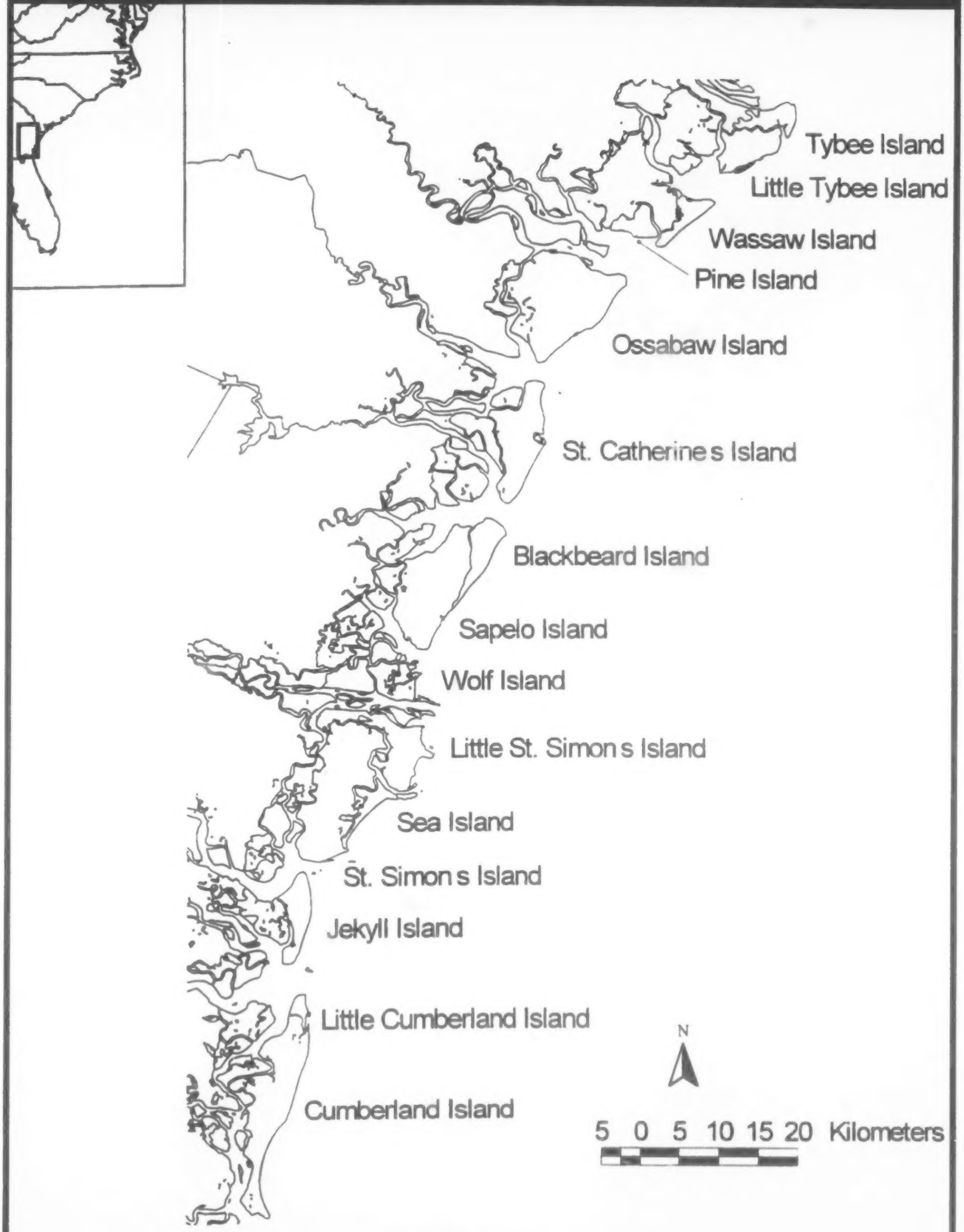
9) Of the islands with the greatest number of nests, name the ones which are federally regulated. Give three reasons why these islands might have greater number of nests than privately held islands.

10) Of the islands with the greatest number of nests, name the ones which are state regulated. Is there a great difference between these islands' nest numbers and the federally protected islands' nest numbers? Give at least three reasons for why you might see a difference.

11) Study the section of the map that includes St. Simons, Sea, and Little St. Simons Islands. Is there a difference in nest number between these three islands? Give three reasons that could account for the differences.

12) What features besides ownership type might cause these differences in density? Examples might include: roads, housing etc.

MAP OF GEORGIA BARRIER ISLANDS


Tybee Island
Little Tybee Island
Wassaw Island
Pine Island
Ossabaw Island
St. Catherine s Island
Blackbeard Island
Sapelo Island
Wolf Island
Little St. Simon s Island
Sea Island
St. Simon s Island
Jekyll Island
Little Cumberland Island
Cumberland Island
N
5 0 5 10 15 20 Kilometers

Location of study area in Georgia, 1999

TURTLE NESTING DATA SHEET

Island (from north to south)	Total upland acreage	Length of beach (km)	Type of ownership	Year of designation	Number of Loggerhead nests
Tybee	1500	5.8	Private developed		8
Little Tybee	600	5.5	Georgia Department of Natural Resources		**
Williamson	256	2.3	Georgia Department of Natural Resources	1971	**
Wassaw	2500	11.3	National Wildlife Refuge (USFWS)	1969	125
Pine		1.8	U. S. Fish and Wildlife Service		7
Ossabaw	11,800	18	Georgia Department of Natural Resources	1978	295
St. Catherines	6870	18.4	Private	1969	125
Blackbeard	3900	11.3	National Wildlife Refuge (USFWS)	1940	193
Sapelo	10,900	8.1	Georgia Department of Natural Resources, R. J. Reynolds Foundation, residents of Hog Hammock, National Estuarine Research Reserve and Wildlife Refuge (NOAA)	State: 1969 Federal: 1976	98
Wolf	250	3.6	National Wildlife and Wilderness System (USFWS)	1930	2
Little St. Simons	2300	11.2	Private	1900	30
Sea	1200	8.5	Private developed	1927	105
St. Simons	12,300	8.8	Private developed		2
Jekyll	4400	13.2	Georgia State Park private development	1947	136
Little Cumberland	1600	4.6	Private		30
Cumberland	15,100	28.2	National Seashore (USNPS)	1972	261

**insufficient number of nests/burdensome to count

Glossary

Abyssal: referring to the deep sea or abyss

Bank: an undersea elevation rising from the continental shelf

Bathymetry: the measurement of depths of water in oceans, seas, and lakes

Bay: a small body of water set off from the main body, an inlet of the sea usually smaller than a gulf

Benthic: near or on the bottom

Canyon: a deep narrow valley with steep sides and often with a stream flowing through it

Cape: a point or extension of land jutting out into water as a peninsula or point

Continental Shelf: an old, wave-cut terrace gently sloping seaward

Continental Slope: beyond the shelf, the slope descends more steeply into the ocean shelf

Creek: a stream of water smaller than a river, often a tributary to a river

Davidson Current: warm ocean current flowing northward between the shoreline and the California Current along the West Coast of the U.S. during winter months

Degree: basic unit of measurement of latitude and longitude. There are 90 degrees of latitude between the equator and either pole, and there are 360 degrees of longitude that encircle the Earth

Detritus: particles of debris from decaying plants and animals

Ecology: scientific discipline involving interrelationships among organisms and their environments

Ecosystem: an ecological community together with its environment, functioning as a unit

Estuary: where river currents meet and are influenced by oceanic tides

Fan: (also called an alluvial fan) deposits from a stream that form gently sloping fan-shaped sediments, often seen at the base of a hill or gorge

Fathom: a unit of length equal to 6 ft and used principally in measuring depths in the marine environment

Geography: the science or the study of Earth and its life; a description of land, sea, air and the distribution of plant and animal life including people and cities

Geology: the science or the study of the Earth and its history as recorded in rocks

Gulf: a part of the ocean or sea extending into the land

Habitat: the environment where a particular plant or animal grows or is normally found

Hydrology: the science or the study of bodies of water, such as the measurement of flow in streams

Island: land surrounded on all sides by water and smaller than a continent

Knot: a unit of speed with a built in meaning per hour. One knot equals one nautical mile per hour, which is about 1.15 statute (or land based) miles per hour

Latitude: the angular distance north or south of the equator, measured in degrees along a meridian, a on a map or globe

Longitude: the angular distance on the Earth, as on a globe or map, east or west of the prime meridian at Greenwich, England, to the point on the Earth's surface for which the longitude is being ascertained, expressed in degrees, or in hours, minutes or second

Glossary

Meander: a turn or winding area of a stream

Monitoring: methods designed to detect changes in an ecosystem over time, such as changes in physical conditions, changes in distribution or abundance of organisms, or changes caused by human and natural events

Mount: a high hill

Midden: a refuse heap, a dump, especially referring to Indian kitchen middens

Nautical Mile: a unit of length used in sea and air navigation based on the length of one minute of arc of a great circle; an international and U.S. unit equal to 1,852 meters or about 6,076 ft.

Oceanography: study of the physics, chemistry, biology and geology of the world's oceans

Peak: the top of a hill or mountain ending in a point

Pelagic: refers to the open water of the oceans, lacking association with the shore or the bottom

Plankton: plants and animals that swim weakly, or not at all, and drift with ocean currents

Point: a projecting area of land or a sharp prominence

Predator: an animal that kills and eats other animals

Range: a series of mountains

Remotely Operated Vehicle (ROV): an unmanned craft built to go beneath the ocean surface for the purpose of studying the marine environment. It is operated "remotely" from a ship

Ridge: (on land) a range of hills or mountains (on the ocean floor) an elongated elevation on the ocean bottom

River: a natural stream of water usually large and long

Sanctuary: a safe place of refuge and protection

Site Characterization: a study of an area that includes knowing the components of an ecosystem (such as algae, plants, animals, water temperature, etc.), the condition of the ecosystem in the past, its present condition, and enough understanding of how the ecosystem works to predict future conditions given certain variables

Sea Level: the level of the surface of the sea, a midpoint between the high and low tide

Seamount: a submarine mountain rising above the deep sea floor

Stakeholder: a citizen with a vested interest in a certain resource

Submarine Canyon: a long, narrow, steep-walled undersea valley

Submersible: a vehicle with or without a human inside that is capable of operating underwater and is used to explore the depths of the ocean

Substrate: any surface on which a plant or animal lives on, which a material sticks

Taxonomy: scientific classification of animals and plants

Transect: a monitoring research technique that marks a transverse along which measurements can be taken

Topography: a graphical representation of the physical features of a place or region on a map

Upwelling: a movement of nutrient-rich water to the surface, caused by wind-driven surface currents that carry water away from the continents

Valley: a long, low area of land usually between hills or mountains drained by a river

Watershed: a region or area connected by a body of water, rivers and drainage

Sustainable Seas Expeditions
Teacher Resource Book
EVALUATION FORM

Thank you for taking the time to complete this Evaluation Form. Your comments will help us improve the educational materials that we develop in the future.

1. **Circle the grade level(s) you teach:**

6 7 8 9 10 11 12

2. **I teach (circle all that apply):**

Geography Life Science Physical Science Earth Science Social Science

Other: ______________________

3. **Rate the Teacher Resource Book in terms of quality.**

High quality				*Low quality*
1	2	3	4	5

4. **Rate the Teacher Resource Book in terms of usefulness.**

Very useful				*Not useful*
1	2	3	4	5

5. **The materials and activities are written at a level appropriate for a high school audience.**

Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
1	2	3	4	5

6. **These materials address my needs to teach to the local, state, and national standards in science and geography.**

Agree *Disagree*

7. **The Investigations I used in my classroom were (circle all that apply):**

Investigation 1: What are National Marine Sanctuaries? (see Unit 1)

Investigation 2: A Closer Look at One Sanctuary (see Unit 1)

Investigation 3: Planning an Expedition (see Unit 1)

Investigation 4: Designing a Submersible (see Unit 1)

Investigation 5: Using Charts to Explore Marine Sanctuaries

Investigation 6: How Would an Oil Spill Affect a Marine Sanctuary?

Investigation 7: Sea Turtle Lifecyles

8. **The amount of time my students spent on *Sustainable Seas Expeditions* was:**

0–1 hours	1–2 hours	3–5 hours	6–8 hours	8–10 hours	More than 10 hours

9. **Was there an *Expeditions* Student Summit in your area?**

Was there an *Expeditions* Student Summit in your area?	Yes	No
If yes, did your students attend?	Yes	No
Did your students share their projects with others?	Yes	No

If yes, how valuable was this experience to their learning?

Very valuable				*Not very valuable*
1	2	3	4	5

10. **I am interested in participating in *Sustainable Seas Expeditions* again next year.**

Strongly agree	*Agree*	*Not sure*	*Disagree*	*Strongly disagree*
1	2	3	4	5

11. **Circle the parts of the *Sustainable Seas Expeditions* Teacher Resource Book that you feel need improvement:**

Background Information   Investigations   Teacher Resources

12. **Suggestions for improvement:**

13. **Did you notice student learning as a result of using these materials? Please explain your observations and conclusions.**

14. **Are there any activities, background information, or resources for teachers and students that you recommend adding to or deleting from these materials?**

Please send your completed Evaluation Form to:
Sustainable Seas Expeditions
Attention: Teacher Resource Book
735 State Street, Suite 610
Santa Barbara, CA 93101

Sustainable Seas Expeditions

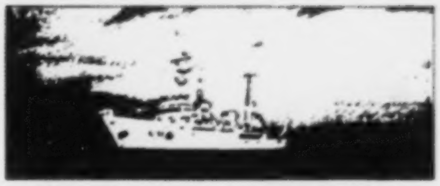
NSTA National Science Teachers Association

NATIONAL MARINE SANCTUARIES

NOAA

NATIONAL GEOGRAPHIC SOCIETY

Sustainable Seas Expeditions



NOAA ship McArthur supports the SSE missions.

DeepWorker 2000 explores the marine sanctuaries.

Students-at-Sea examine a plankton sample.

Community participation in SSE at an Open House.

The National Marine Sanctuary Program serves as the trustee for the nation's system of marine protected areas to conserve, protect, and enhance their biodiversity, ecological integrity, and cultural legacy. The twelve national marine sanctuaries protect some 18,000 square miles of oceans and coasts. Resource protection is the highest priority for the sanctuary program, and action is being taken to ensure that these important ecosystems are preserved for future generations.

In April 1998, the National Geographic Society, the National Oceanic and Atmospheric Administration, and the Richard & Rhoda Goldman Fund announced an unprecedented mission for the oceans. With a $5 million grant from the Goldman Fund, the Society launched Sustainable Seas Expeditions (SSE), a five-year project of deep-water exploration and public education in NOAA's national marine sanctuaries.

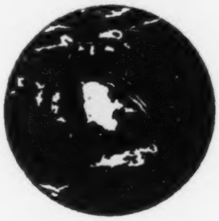
Dr. Sylvia Earle, a National Geographic Society Explorer-in Residence, is leading the Expeditions, using the DeepWorker one-person submersible, which can dive to depths of 2,000 feet. This technology enables the Expeditions to use the excitement of exploration and state-of-the-art photography to engage interest in the vulnerable oceans and marine conservation.

All photography courtesy of Kip Evans, National Geographic Society.

SE

Sustainable Seas Expeditions

EXPLORATION



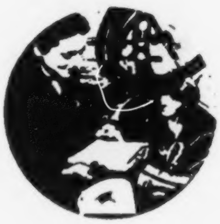
Specifications of the DeepWorker Submersible:

Weight in air: 3,500 lbs. • Operating depth: 600m (2,000 feet)

Payload: 300 pounds, including pilot • Life Support: 80 hours

Speed: 3-4 knots maximum • Crew: One pilot

DISCOVERY



Sustainable Seas Expeditions conduct systematic exploration, mapping, photodocumentation, species inventories, and habitat characterization of the national marine sanctuaries. Expedition scientists are developing monitoring protocols and assessing the potential to use new tools, such as DeepWorker, for research and management.

KNOWLEDGE

Sustainable Seas Expeditions has launched an intensive public education campaign that captures the interest and imagination of students, teachers, and communities and inspires learning about the national marine sanctuaries through books, magazines, videos, events, at-sea experiences, workshops, and the Web.

For more information on SSE and the national marine sanctuaries, please visit www.nationalgeographic.com/seas and www.sustainableseas.noaa.gov.

Seamour

Artificial Reef

pores

Sustainable S

In April 1998, the National Geographic Society, the National Oceanic and Atmospheric Administration (NOAA), and the Richard & Rhoda Goldman Fund announced an unprecedented mission for the oceans. With a $5 million grant from the Goldman Fund, the Society launched the Sustainable Seas Expeditions, a five-year project of ocean exploration and conservation to NOAA's National Marine Sanctuaries.

The 12 marine sanctuaries conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of the nation's marine environment. Ranging from American Samoa to New England, they include Pacific and Atlantic haunts of whales, sea lions, sharks, rays, and turtles; significant coral reefs and kelp forest habitats; and the remains of the USS *Monitor* off North Carolina.

Beginning in April 1999, Dr. Sylvia Earle, National Geographic Society Explorer-in-Residence, and former national marine sanctuary director, Francesca Cava, will lead the Expeditions to the 12 marine sanctuaries. The Expeditions' goals are to:

(1) undertake the first sustained exploration of the sanctuary system to depths of 600m (2,000 feet),

(2) photodocument the natural history of each sanctuary's plants and animals, and,

(3) help establish monitoring protocols to document the long-term health of the marine sanctuaries.

Ultimately, through opportunities for ground-breaking exploration, compelling images and video, and public involvement, Sustainable Seas Expeditions is designed to generate greater support for marine sanctuaries and in turn increased conservation of our ocean.

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as Expeditions

Deep

The Sustainable Seas Expeditions will explore the deep space of the ocean using innovative DeepWorker 2000 submersibles. These small, maneuverable submersibles provide the gift of time to pilots who can now explore at depths unattainable using conventional means, even within normal diving range. Like astronauts reporting their direct view of Earth from space, DeepWorker 2000 aquanauts will be able to capture a sense of the ocean from within.

The deep sea is as uncharted as the vast interior was when President Jefferson commissioned Lewis and Clark to explore and document unknown resources in the American West. The Sustainable Seas Expeditions has the potential to produce significant discoveries and extraordinary educational experiences for millions, and the data gathered can provide stronger foundations for marine research and conservation policies.

The Sustainable Seas Expeditions Web page **www.nationalgeographic.com/seas** and **www.sustainableseas.noaa.gov** will bring the thrill of exploration to the world through daily mission logs, photo galleries, virtual expeditions, educational materials, summary of investigations, and on-line discussions with marine researchers.

"Whatever else is achieved, the ultimate success will be in the project's overall impact on dispelling ignorance about the sea," said Project Director Sylvia Earle. "With knowing comes caring, and with caring there is hope that an ocean ethic will arise that will secure a sustainable future for ourselves and for the seas."

The success of the Sustainable Seas Expeditions will depend on the participation of many collaborators. To date, the Society and NOAA have been joined by the U.S. Navy, NASA, Monterey Bay Aquarium Research Institute, Mote Marine Laboratory, Center for Marine Conservation, and SeaWeb—and the list continues to grow.

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Communication systems include a modified Imagenex sonar, which allows standard scanning and ultra-high resolution for short range scans. Ocean sounds are recorded with a directional hydrophone. Video cameras allow the pilot to record the dive. VHF communications allow contact with surface support personnel.

The robotic arms are water powered manipulators that can extend 3.6m (12 feet).

Specifications

Weight in air: 1.3 tons (1,300 kg).

Operating depth: 600m (2,000 feet).

Payload: 250 pounds (113 kg), including pilot.

Life Support: 106 hours.

Speed: 3-4 knots maximum.

Crew: One Pilot.

NOAA's
National Ma

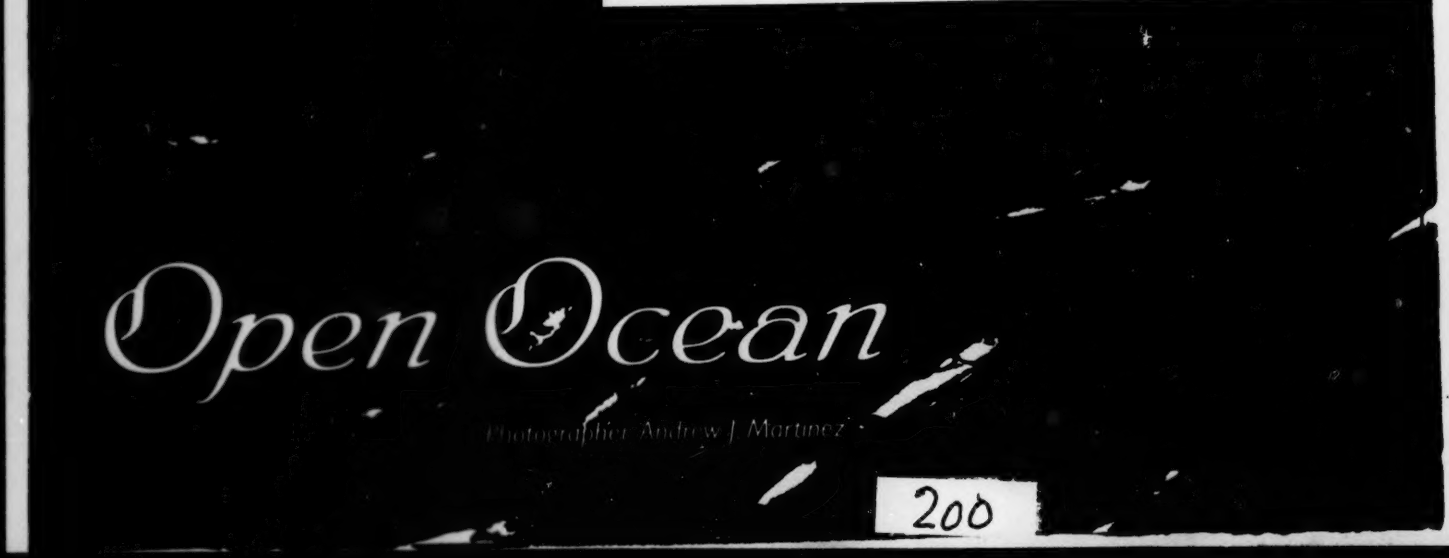
In 1972, as Americans became more aware of the intrinsic ecological and cultural value of our coastal waters, Congress passed the National Marine Sanctuaries Act. This law authorizes the Secretary of Commerce to designate our most cherished marine waters as national marine sanctuaries, to protect and manage their priceless resources.

In the last 25 years, 12 national marine sanctuaries have been created. They include nearshore coral reefs and open ocean, rich banks and submarine canyons, intertidal areas and sheltered bays. National marine sanctuaries range in size from the smallest of neighborhoods (Fagatele Bay, American Samoa—1/4th sq. mi.) to larger than the state of Connecticut (Monterey Bay—5,328 sq. mi.). Sanctuaries harbor a dazzling array of plants and animals, from great whales to tiny, brightly-colored sea snails. These protected waters provide a secure habitat for species close to extinction and protect historically significant shipwrecks and prehistoric artifacts. They serve as natural classrooms for students of all ages and as living laboratories for scientists.

Sanctuaries are cherished recreational spots for diving, bird watching, and sport-fishing. They also support valuable commercial industries such as marine transportation, fishing, and kelp harvesting. The perpetual challenge of managing these areas is maintaining the critical balance between environmenta protection and economic growth.

National marine sanctuaries represent our riches as a nation. They are treasures that belong to every citizen, and to every generation of citizens to come. We have the right to enjoy them and—importantly—the responsibility to sustain them for the long term.

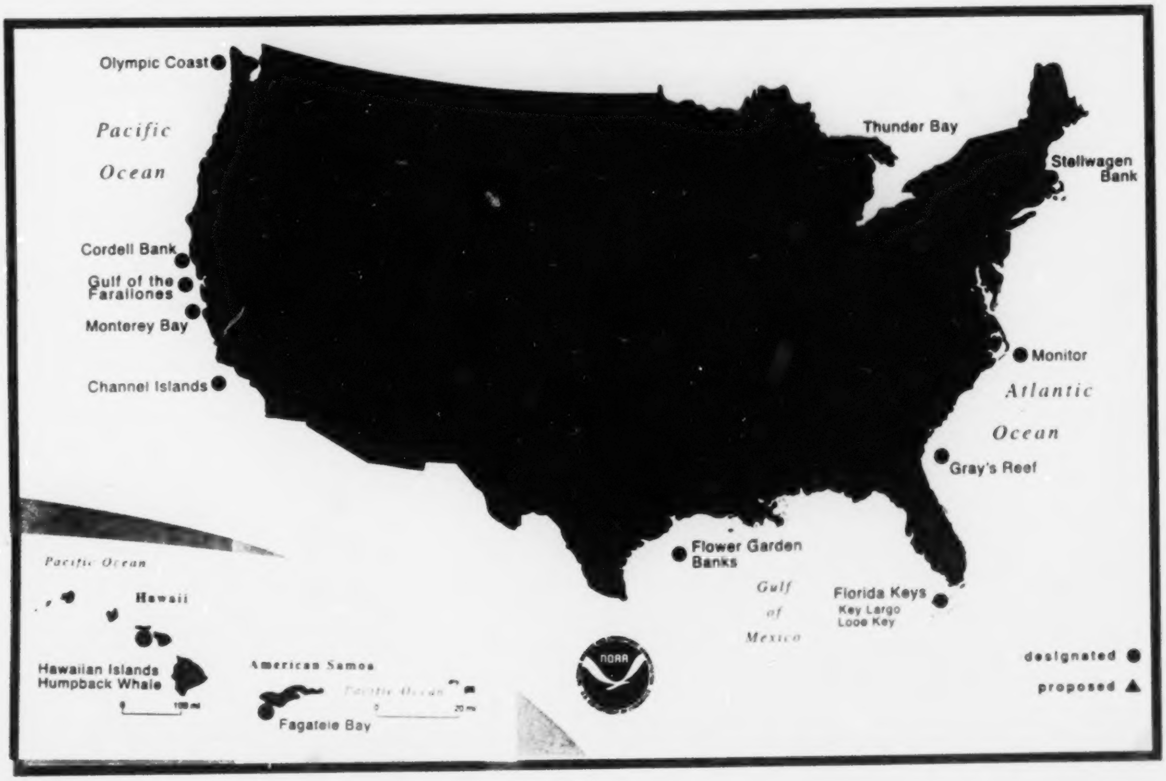
Rocky S



Open Ocean

Photographer Andrew J Martinez

rine Sanctuaries


Olympic Coast
Pacific Ocean
Cordell Bank
Gulf of the Farallones
Monterey Bay
Channel Islands
Thunder Bay
Stellwagen Bank
Monitor
Atlantic Ocean
Gray's Reef
Flower Garden Banks
Gulf of Mexico
Florida Keys
Key Largo
Looe Key
Pacific Ocean
Hawaii
Hawaiian Islands Humpback Whale
American Samoa
Pacific Ocean
Fagatele Bay
NOAA
designated ●
proposed ▲

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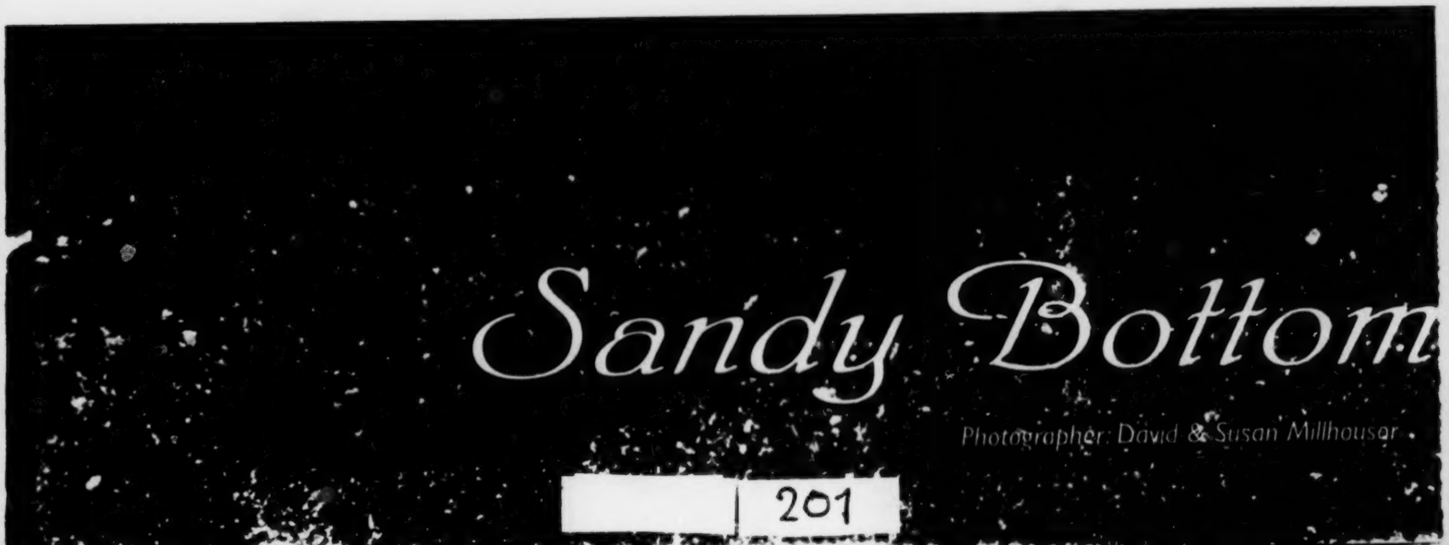
Sandy Bottom

Photographer: David & Susan Millhouser

SE

Coral Reef

Photographer: Mike White

Worker 2000

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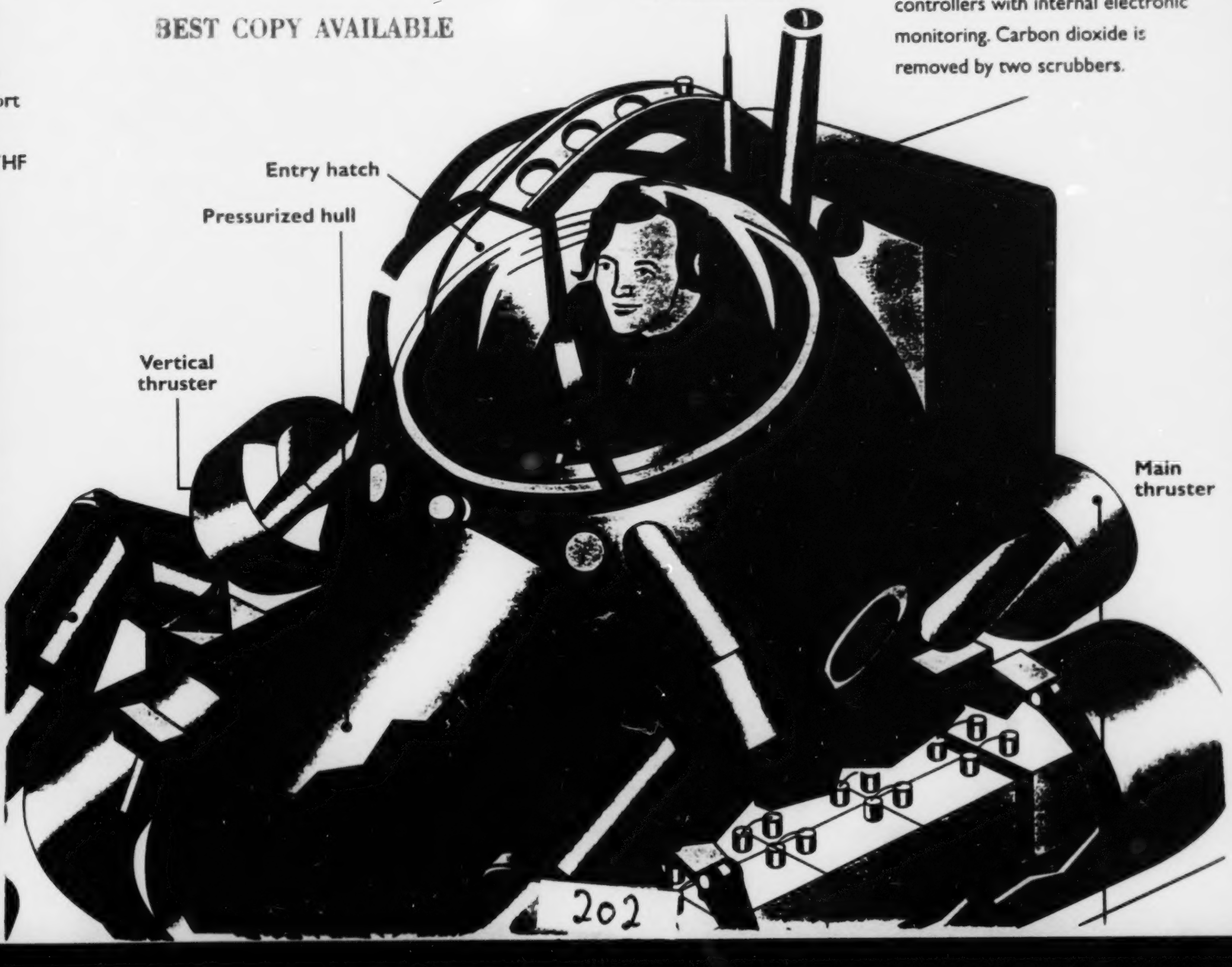
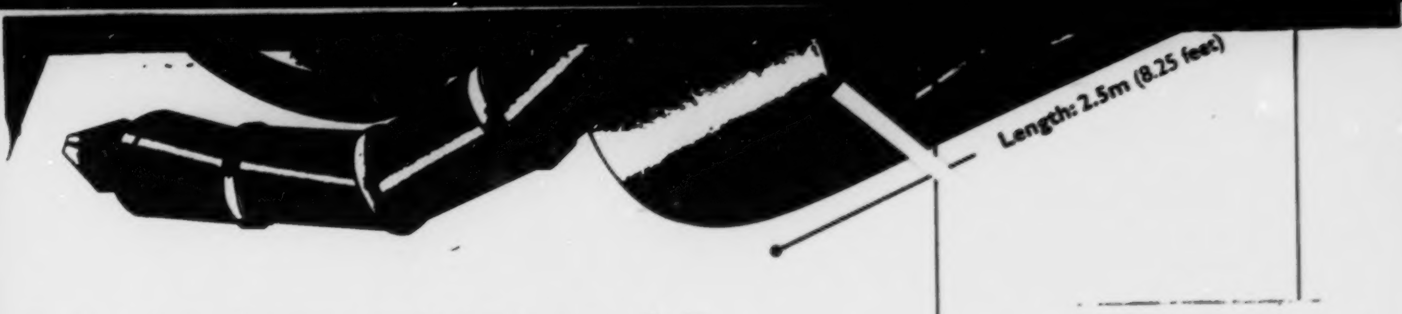


Life support systems include two external oxygen cylinders and two redundant, mechanical oxygen controllers with internal electronic monitoring. Carbon dioxide is removed by two scrubbers.

Communications
ort
HF
Entry hatch
Pressurized hull
Vertical thruster
Main thruster



Ten 12 volt batteries

Maneuvering is controlled by the main one horse-power thrusters plus two angled vertical thrusters for lateral movement. A 2.84m^3(100 ft.^{3}) ballast air tank provides additional control of depth.

DeepWorker 2000 is a one-person submersible about three-quarters the size of a small car. This remarkable vehicle can dive to a depth of 600 meters (2,000 feet) and provide life-sustaining oxygen for its pilot for up to 106 hours (in an emergency—normal operations rarely exceed 12 hours). Without tethers or connecting lines to its support ship, DeepWorker gives its pilot amazing mobility and the gift of time—a precious commodity for humans in the underwater environment.

Because DeepWorker is a directly operated vehicle—or D.O.V.—it moves independently of its surface support ship. The sub is driven by a trained pilot who may be a scientist, a technician, explorer or even a journalist, teacher or poet. The sub's simple, yet sophisticated, technology means that the pilot and the passenger are combined—one person can pilot the craft and still carry out observations and scientific experiments. Eliminating the second occupant from the sub reduces its weight, complexity, and the expense of operation.

DeepWorker's small size and light weight make it more mobile than most other submersibles. Measuring just over two meters long (eight feet), it fits easily on a truck or trailer for traveling overland. At the dock, it can be loaded on a ship with a relatively small crane, and at the dive site, the 1,300 kilogram (1.3-ton) sub can be launched with many types of common equipment. Older, heavier systems require dedicated launch machinery and usually dive from only a specially-constructed support ship. DeepWorker can be supported by many ships.

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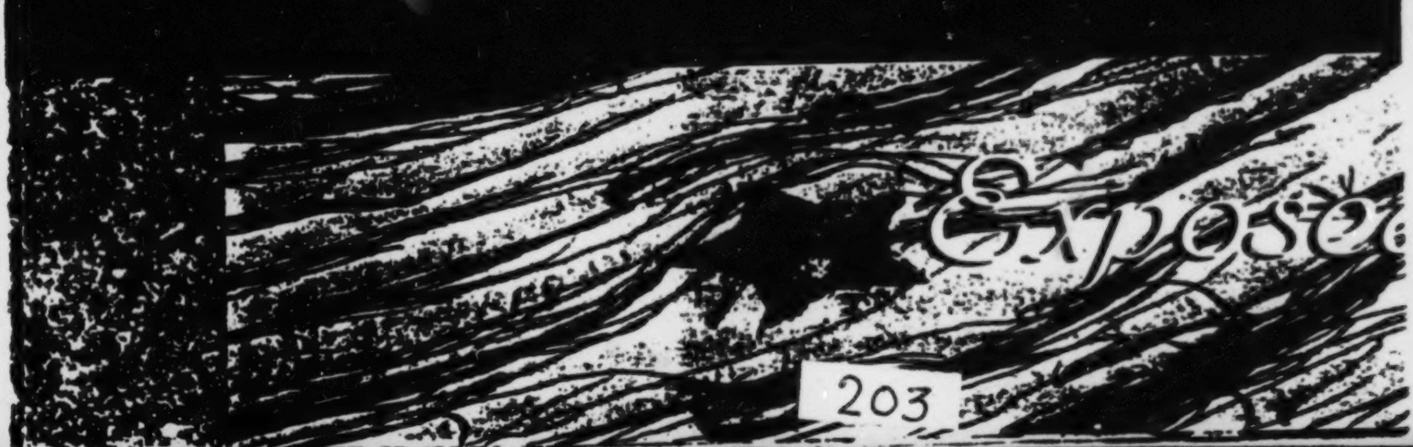

Kelp Forest

Photographer: Passage Productions

Time Line of O

300 b.c.

Greeks diving for sponges breathe air trapped in kettles lowered underwater.

1690

In England Edmond Halley invents a diving bell which will allow divers to descend to more than 50 feet underwater.

1800

U.S. inventor Robert Fulton tests his submarine, *Nautilus*, in France.

1930

Using a bathysphere, naturalist Dr. William Beebe and designer Otis Barton dive to 1,428 feet in waters off Bermuda.

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cean Exploration

1960

In the bathysphere *Trieste*, Jacques Piccard and Lt. Don Walsh, USN, descend to 35,000 feet in the Mariana Trench, the deepest known area in the sea.

1979

Dr. Sylvia Earle, in a Jim suit, rides the submersible *Star II* to the seafloor, 1,250 feet off Oahu, Hawaii.

1984

DeepRover, a deep-sea submersible, is launched, and four people make record solo dives to 3,280 feet.

1999

DeepWorker submersibles allow Sustainable Seas Expeditions pilots to explore and document the U.S. National Marine Sanctuaries.

Seagrass Meadows

Photographer: Bill Keogh

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Beaches

Photographer: Sea Studios, Inc.